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REMARKS ON THE GEOGRAPHY OF SETTLEMENT IN THE NILE VALLEY DURING HELLENISTIC TIMES

BY

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Introduction.

The Hellenistic (Ptolemaic-Roman-Byzantine) period of Egyptian history embraces a time span of over a millenium. The beginnings of contact with the Greek world date back to the founding of Naucratis by the Miletians, apparently during the reign of Pharaoh Amasis (578-525 B. C.), and Greek mercenaries figured prominently in the wars of the 26. Dynasty of Sais and onwards, until the close of the Ptolemaic period. Factories such as at Tanis and Daphnae were founded by Hellenic merchants so that even before Alexander succeeded the Persian satrap at Memphis in the autumn of 332 B. C., ancient Egyptian culture had been exposed to foreign elements almost three centuries. The succeeding millenium until the Arab conquest under Amr ibn al-As in A. D. 639-641 represents a curious span of Egyptian history that witnessed the gradual transition from the ancient dynastic Egypt to the modern islamic Egypt. Thus although the Ptolemaic-Roman-Byzantine period is superficially a unit, characterized by the introduction, partial success, eventual rejection and decay of Hellenism, it consists, fundamentally, of a diversified phase of transition, of subtle evolution from the ancient to the modern. Just as a good case can be made for assigning the Ptolemaic period as an appendage to dynastic Egypt, so could one consider the Coptic era a full-fledged precursor to modern Egypt. In the intervening three and a half centuries of Roman rule to the reign of Constantine A. D. 323-337 considerable changes had taken place, of which, from the geographical point of view, probably the most significant was the disappearance of the *nomes*.

In attempting this historic-geographic discussion of the salient factors of the geography of settlement between 332 B. C. and A. D. 641 we are then not treating a coherent period of basic uniformity. The remarks made here are by no means designed to be exhaustive, we have merely attempted, for the first time, to analyze the far-reaching changes of the period, be they administrative, economic, social or physical, in as far as they concern the geographer, and from the geographer's perspective. There will obviously be many an error or omission in detail or in interpretation. But if the suggestions so offered may stimulate further and more exhaustive research they will have served their purpose. For practical reasons the investigation has been limited to Middle and Upper Egypt, with which the writer is most familiar, specifically from the apex of the Delta to the region of the First Cataract.

The source materials are manifold. Most complete and illustrative are the varied literary sources, ranging from an innumerable collection of Greek and Coptic papyri to invaluable descriptions of the classical authors. This material is adequately complemented by the archaeological evidence, and to a somewhat lesser degree by a limited amount of geological evidence. Some of the outstanding basic literary references are E. Amélineau's *La Géographie de l'Egypte à l'Epoque Copte* (1893), K. Wessely's *Topographie des Faijum in Griechischer Zeit* (1904), and J. Ball's *Egypt in the Classical Geographers* (1942). The archaeological evidence has been made readily accessible in B. Porter and R. L. B. Moss, *Topographical Bibliography of Ancient Egyptian hieroglyphic Texts, Relief and Paintings* (1927-1951), and first contributions to the geological evidence have been made by G. Caton-Thompson and E. W. Gardner (1929, 1934) and K. W. Butzer (1959, 1960).

Population Density and the Significance of the Greek Colonies.

The Ptolemaic-Roman-Byzantine epoch was essentially one of foreign domination, at least after the Roman conquest in 30 B. C. when Egypt was reduced to a province ruled from abroad. Even though of foreign blood the Ethiopian dynasts of the 25. Dynasty (715-656 B. C.) and the Macedonian dynasts after 323 B. C. exercised a personal rule in the interest of public welfare and prosperity. And they considered themselves as legal successors of the pharaohs, doing lip hommage to Egyptian customs and institutions. The enlightened rule of the earlier Ptolemies, whose economic policy was « to accumulate the maximum amount of wealth, to incur the minimum of expenditure» (C. Préaux 1939), brought a high level of material prosperity to Egypt comparable with that of the 26. Dynasty [1], or even with some of the more flourishing phases of the New Kingdom.

Although there are no official census records available for any of the periods under consideration, several literary sources allude to the great population of the country. One need pay no special attention to the remark of Theocritus, repeated by Diodorus (I. 31.7), that there were 33,333 towns in Egypt under Ptolemy I Soter (323-285). But Diodorus continues that (I. 31-8) the population of old was about 7,000,000 and that it remained so down to his day [2]. A little more than a century later Flavius Josephus (II, 16, 4, 385) gives the population of Egypt with 7,500,000—exclusive of Alexandria, whose free population alone according to Diodorus (XVII, 6, 52) was at least 300,000. This estimate of Josephus was in good possibility calculated from head-tax records or taken from population lists. It does therefore have a certain reliability. As such it would seem that the population density achieved in the Graeco-Roman period was not rivalled again until after 1882 (cf. P. Jouguet 1911, p. 44). In the intervening centuries the population may have been as low as 2,000,000 at times.

The archaeological evidence supports this supposition very strongly, for the settlement remains and cemeteries of the Hellenistic period preserved on the edge of the desert are simply unlimited and outweigh the sum total of older and younger remains by a total of several to one (cf. W. Kaiser and Butzer, 1960). This is understandable as a response

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[1] For what it is worth, Herodotus (II, 177) states that there were not less than 20,000 inhabited cities (and villages) in Egypt during the reign of Amasis.

[2] Diodorus visited Egypt between 60 and 56 B. C., and had probably completed his *Library of History* before 30 B. C. The version of the text adopted at this point has the authority of such specialists as E. Meyer, U. Wilcken and P. Jouguet.

to the government policy of colonization of the marginal lands, amply testified by literary sources and discussed further below. Another basis of confirmation is provided by the record of villages preserved from the Fayum and analyzed by Wessely (1904). The texts record 89 towns and villages there during the Ptolemaic, 141 during the Roman and 198 during the Byzantine period. Obviously these represent only a fraction of the extant villages, depending upon the completeness of the literary record. Yet the reliable catastral survey of A. D. 1315 noted somewhat less than 100 villages in the Fayum, the French survey of 1799-1800 only 69. Accepting the notable density of the population, which is confirmed by most classical authors, the dualism of the population must next be considered.

As mentioned, Greek colonization, commercial enterprise and mercenary activity in Egypt had a tradition of almost three centuries before the arrival of Alexander the Great. This influence was however almost exclusively limited to Lower Egypt, in particular to the Delta, Memphis and Babylon, the site of Old Cairo. With the establishment of Ptolemy Soter a horde of mercenary Greeks, Macedonians, Persians and hellenized Asiatics were settled in Egypt, while Greek scientists, technicians and administrators were invited to participate in the land-reclamation projects or the establishment of a civil-service bureaucracy on the Greek model. The numbers of mercenaries who accompanied Ptolemy Soter to Egypt can hardly have exceeded 25,000, if we consider that Alexander's army even at Gaugamela numbered only 7000 cavalry and 40,000 foot soldiers. In other words, the numerical position of the Greek-speaking population, despite later immigration, and a limited absorption of Egyptians, must always have been insignificantly small in comparison to the great mass of the Egyptian population, probably less than 2 %. Their importance was however out of all proportion in that they formed the core of the administration throughout the country, and that the bulk of the Greeks were settled in a few small urban centers and rural enterprises.

There were three self-governing Greek cities in Egypt meriting the term *polis,* the older town of Naucratis, the new city of Alexandria founded by Alexander in 331 and the town of Ptolemais (el Manshah) founded

by Ptolemy Soter a generation later. Both of the latter at least were founded near or on the sites of older indigenous villages. Both of these were laid out on a rectangular grid pattern, Ptolemais probably being modelled on Alexandria (Jouguet 1911, p. 7). The Greeks of these cities were the only full-fledged citizens of the country, they were autonomous—although effectively under royal control, and had their own laws, which incidentally prohibited intermarriage with the Egyptians.

The remainder of the urban Greeks was scattered among the nome capitals or *metropoleis,* which although fair-sized towns, had little urban character and were probably overgrown villages. Here the Greek-speaking population lived in separate quarters, and although without full rights of citizenship—they had no franchise outside of the three *poleis*—attempted to preserve individual culture. Above all the *gymnasium* played the central core of their intellectual life. The Greek element was particularly strong in Arsinoe (Madinet el-Fayum), Hermopolis magna (Ashmunein), Lycopolis (Asyut) and Heracleopolis (Ihnasiya), but even here there was no popular assembly or senate, authority was vested in the hands of a royal appointee.

The rural population of foreign tongue in the Nile Valley consisted of mercenary colonies, whose members were allotted land, but remained liable to military service. These were however exempt from the *corvee,* which was apparently only imposed upon the rural Egyptians. The Macedonian mercenaries were mainly settled in large sections of the Fayum, although there were probably some settlements of this kind in different marginal lands of the Delta, and of the Valley in the nomes of Memphis, Cynopolis (Sheikh Fadl) and Thebes. These settlers in the country and in the villages did not maintain an exclusiveness as did those in the nome capitals; they intermarried freely with the natives from the beginning and very gradually were absorbed into the Egyptian population.

Elsewhere however the Egyptians were essentially treated as a conquered race, excluded from the army and higher administrative posts. They were subjected to periodic forced labour on public works, and generally were reduced to the status of tenants, employees, artisans, although members of the native aristocracy were more often admitted to higher

posts, both civil and military, in later Ptolemaic times. This dualism of a stratified society consisting of a foreign ruling minority and a governed native majority was reflected even in the law courts, Greeks and Egyptians were subject to different civil law codes and district law courts. Despite the mixed origins of the foreign population [1] the common language was the *koine* Greek, which was eventually adopted by the Jewish population as well. In Upper Egypt there were Jewish minorities at Elephantine since the 4th century, at various localities in the Fayum since the 3rd century B. C. Already at this date these small urban communities were particularly active in commerce and finance (Jouguet 1911, p. 18-22).

The Nomes as Economic Units.

From the early periods of the Egyptian kingdom the country had been divided into nomes or provinces. The role of the governor or nomarch was admittedly reduced in stature during the Ptolemaic period to that of a financial official and replaced in function by the *strategos,* originally a military commander, eventually *de facto* governor. Yet the nome remained the basic administrative, and simultaneously economic, unit of the country. The entire administration—political, judicial, fiscal—was concentrated in the nome capital (Jouguet 1911, p. 272 ff.). The central authority of the royal bank and above all the state granary, for storage of the produce exacted as taxation, was situated there. The royal estates, comprising the greater part of the arable land, were administered from here, and in Roman and later times the great landowners resided in the *metropolis.* And aside from being the administrative and economic core of the nome, whatever cultural life was associated with the temple priesthood or the gymnasia was concentrated here.

In a similar manner the major arteries of Egyptian commerce and traffic, the Nile, the Bahr Jusef, and possibly a few of the larger canals, were accessible solely through the official provincial port or harbour. Practically all of the provincial products, agricultural or industrial, were exported through the nome harbour (Jouguet 1911, p. 276-277),

[1] Thus even in the early Roman period Arsinoe had separate quarters for Greeks (Hellenes), Macedonians and Thracians.

which was a seat of the provincial customs. In other words the nome artificially regulated all economic enterprise into specific channels. In this fashion the nome capital and its harbour retained their significance through millenia, and there was little chance for other settlements, possibly with better location, to succeed them. Thus, we know the ancient Egyptian nome patterns remained almost stationary into Ptolemaic times. The traditional patterns and channels were so strong that even the major cemetery, the nome *necropolis,* remained at specific locations for millenia. In Table 1 the nomes, *metropleis,* ports and *necropoleis,* as they were in Ptolemaic times, are listed for Upper Egypt. To these may be added the Lower Egyptian nomes I. (Memphis), XII. (Letopolis = Ausim) and XIII. (Heliopolis).

In most cases the *metropolis* was situated on or very near the banks of the Nile, so that it played the role of its own harbour. The oldre nome capital of VIII., Abydos, and X., Aphroditopolis (Kom Ishqaw), were probably located on or near to the Sohag Canal, running from the Nile bend near Hammadi to Asyut in Islamic times. This canal was quite large, and possibly represents a former natural branch of the Nile as is the Bahr Jusef. After the founding of Ptolemais on the Nile by Ptolemy Soter, Abydos lost its ancient importance. Similarly Aphroditopolis, (which in later times very probably had another, Nile harbour near its *necropolis* at Qaw) was replaced as *metropolis* in Roman times by Antaeopolis (Qaw). This was very probably a case in which the port (or a site near by) replaced a *metropolis* situated in an economic backwater. Hermopolis was almost certainly served by an unknown port near Qulusna or more probably, el Roda, opposite the later founding of Antinoopolis. Temporarily Tanis on the Bahr Jusef may have served such a role too. The city of Antinoopolis was founded by the emperor Hadrian in A. D. 130 near the site of an older village Besa (archaeologically verified since the late 18. Dyn.), and detached from the Hermopolite Nome. We do know for example that the pilgrim Theophanes, travelling from Hermopolis to the Holy Land somewhere during the years A. D. 317-323, completed his travel preparations and embarked for Old Cairo at Antinoopolis (E. Kirsten 1959). Further downstream the port of Heracleopolis is not known for sure, as the position of the *metropolis* with respect to the

TABLE 1

The Upper Egyptian Nome Capitals, Harbours and Necropoleis during the Ptolemaic Period

Nome	Metropolis	Harbour	Necropolis
I.	Elephantine (later Ombos)	(Nile)	Kubet el Hawa, Aswan
II.	Apollonopolis magna (Edfu) ...	(Nile)	el Hassaiya
III.	Ilithyiaspolis (el Kab)	(Nile)	el Kab
IV.	Thebes (Luxor)	(Nile)	Qurna
V.	Coptos (Quft)	(Near Nile)	Quft
VI.	Tentyra (Dandara)...........	(Nile)	el Marashda
VII.	Diospolis parva (Hiw)	(Nile)	Hiw
VIII.	Ptolemais	(Nile)	Abydos
IX.	Panopolis (Akhmin)	(Nile)	el Hawawish
X.	Aphroditopolis (Kom Ishqaw)..	(Canal) Qaw el Kebir?	Qaw (el Itmaniya)
XI.	Hypsele (Shutb)	(Near Nile)	Deir Durunka
XII.	Hierakon (near Abnub?)	(Nile?)	Deir el Gabrawi
XIII.	Lycopolis (Asyut)	(Nile)	Asyut
XIV.	Chusis (Qusiya)	(Near Nile)	Meir
XV.	Hermopolis magna (Ashmunein).	(on Nile? on Bahr Jusef : Tapis)	Tuna-el-Gabal
XVI.	Hebenu (Kom el Ahmar)	(Nile)	Beni Hassan
XVII.	Cynopolis (Sheikh Fadl).......	(Nile)	Sheikh Fadl
XVIII.	Hipponon (Ezbet Qarara)	(Nile)	Ezbet Qavara
XIX.	Oxyrhynchos (Bahnasa)	(Bahr Jusef)	Bahnasa
XX.	Heracleopolis magna (Ihnasiya).	(Bahr Jusef) Sidmant?	Sidmant-el-Gabal
XXI.	Arsinoe (Madinet el Fayum) ...	(Sidmant?) Lahun	Madinet
XXII.	Aphroditopolis (Atfih)	(Near Nile)	Atfih

Bahr Jusef is uncertain. During the first centuries A.D. (Ptolemy, *cf.* J. Ball 1942, p. 85 ff.) it was itself situated on the banks of the Bahr Jusef. At other times it may also have been served by Sidmant el-Gabal, although that town at one period served the Fayum (Jouguet, p. 253-254) in place of Ptolemais harbour (el-Lahun).

The list in Table 1 in effect provides a list of the leading towns of the Nile Valley during the earlier Ptolemaic period, apart from the new towns founded in the Fayum. It also provides a framework of the patterns of settlement, differing somewhat from the present picture of mudiriyas and markazes. Some of the nomes have since been reduced to insignificance, so the nome capitals on the eastern bank of the Nile in Middle Egypt or those once situated on the Bahr Jusef. Instead new centers of population have replaced them, these all being situated on or near the western bank of the Nile.

Expansion of Rural Settlement in Ptolemaic Times.

Before embarking on the well-known land reclamation schemes of the early Ptolemies it may be well to outline the land tenure conditions of Egypt during this period, which are well summarized in M. Rostovtzeff (1941, p. 275-292). First and foremost was the royal land, in theory the king was the only landowner. The peasants were royal tenants, held by free leases. Although not serfs the lessees could not leave their holdings while agricultural operations were under way, and such peasants were at times arbitrarily moved to new marginal lands. A second category of land consisted of the temple estates, managed by the government for the benefit of the temple. The third class of land comprised the allotments to military settlers (*kleroi*) or to high officials (*doreai*). Although both types of holdings were for life only, the former tended to become hereditary as the attached obligation of military duty passed from father to son. At first good, arable was assigned, but with time the *kleroi* were of marginal land and conditional upon its being irrigated or drained and put under cultivation. The *doreai* very often also involved the obligation to reclaim inferior or derelict land. The last class, the so-called privately owned land amounted to smaller market-gardens, fruit groves or vineyards conveyed in hereditary leases. This was generally land not suitable for wheat growing and again meant an extension of the cultivable terrain.

The land tenure system of the Ptolemies was primarily directed toward an areal extension of the productive lands, and coupled with it were complex engineering and agricultural missions led by scientists and technicians from Greece and elsewhere. Outside of the marginal lands of the Delta and the Maryut, details are only known from the Fayum which obviously became the central core of the project initiated by Ptolemy II Philadelphus (285-246 B. C.) and continued by Ptolemy III Euergetes (246-221 B. C.). Smaller areas of marginal land were probably first put under the plough in different parts of the Nile Valley as well. Most of the lands concerned were however not abandoned land, rather higher-lying tracts not too readily available to unaided basin irrigation or poorly drained areas requiring drainage, flood-control and the like.

A similar large-scale expansion of rural settlement had been made in the Fayum during the second half of the 12. Dynasty (1991-1786 B.C.). By controlling the inflow of Bahr Jusef waters through the Hawara Canal Amenemhat III was able to drain an estimated 1100 km^2 of marshland (cf. A. Shafei 1941), although there is no reason at all to believe that he had the Bahr Jusef itself dug (Butzer 1959a, p. 72). In the second phase of land reclamation and rural expansion in the Fayum drainage only seems to have played a small part. According to Caton-Thompson and Gardner (1934), and Caton-Thompson, Gardner and S. A. Huzayyin (1937) the ancient Lake Moeris of the Fayum dropped from -2 m m.s.l. in 4. Dynasty times to *below* -13 m m.s.l. by 285 B. C., with a temporary halt at -11 m inbetween. The geomorphological evidence seems quite sound, and it remains to be proven that there was any 12. Dynasty stand at + 19 m m.s.l. The question has been raised why all pre-Ptolemaic townsites of the Fayum are located above 15 m m.s.l. Two very plausible explanations can be offered. Firstly that the annual inundations occasionally flooded the Fayum well above the major annual level of perhaps -13 m, so rendering the lowlying country poorly drained. The other explanation is that the irrigation waters did not suffice for the country far removed from the outlet of the Hawara Canal. This would be supported by the contention that Philadelphus reexcavated the silted up Hawara Canal (Caton-Thompson and Gardner 1934) as

well as by the analogous situation existing in the last century when no land was cultivated below the Om contour. This would support the hypotheses that insufficient Nile waters had access to the depression so limiting agricultural activity.

As it was Philadelphus lowered the level of the lake further by diverting most of its inflow into a highly complex system of irrigation canals. Two canals were led from the Hawara intake at high levels and led around the margins of the depression, towards the north via Philadelphia including the plains north of Bacchias and Karanis, and towards the south via Tebtynis to the el Gharaq area. A third canal at an intermediate level curved south of Itsa and el Minya past Theadelphia to the southwest corner of the Birket Qarun, where a large area around Dionysias (Qasr Qarun) was irrigated. Only then was the remainder of the waters spread out fanwise to the northwest from a focal distribution point at Arsinoe. In this way the northern, southern and southwestern margins, which have been abandoned since the 2.-4. centuries A. D., implied a one-time minimum enlargement of the cultivated land of the Fayum by 125 square kilometers. The desertion of these lands and their once thriving towns was mainly due to lack of water. This can be attributed to two causes, the silting and neglect of the higher-lying canals (Caton-Thompson and Gardner 1929), and the diminution of Bahr Jusef waters-probably coupled with lower Nile floods—after the 1. century A. D. (Butzer 1959a p. 71-72).

Another form of rural expansion in the marginal lands took place in western Middle Egypt, probably as a result of physical factors. For, in the area of the great belt of dunes extending from Deir el Muharraq and Meir along the margins of the alluvium to the Gebel Deshasha, considerable changes had taken place in historic times (cf. Butzer 1959a, p. 67 ff.; 1959c 1959d). The dunes which had advanced up to several miles east of the Pleistocene gravels during a 1500 year period after about 2350 B. C. were gradually removed. The Bahr Jusef, whose existence is verified by most of the classic authors, shifted westwards and removed the dune fields by lateral planation, depositing the sands further downstream in the river bed. There are numerous well profiles in the area between Dalga, Tuna and Balansura with moderately fine,

highly organic, fluviatile sands interbedded with alluvial clay or silt, and overlying crossbedded aeolian sands. In this region there is a 2 m thick layer of mud and nilotic sands containing Graeco-Roman pottery — a brown rilled and a coarse red ware (cf. Kaiser and Butzer 1960). This layer is again overlain by aeolian deposits, the oldest of which are still Roman. The implications are a phase of highly accelerated Nile-Bahr Jusef sedimentation in Ptolemaic-Roman times, probably associated with somewhat higher flood levels at the time (for details see various articles cited above). Geomorphological and geological evidence leaves little doubt that the Bahr Jusef flowed immediately east of the Pleistocene gravels between Meir and Balansura during several periods of the historic era.

The same area is most profusedly littered with archaeological debris, particularly a series of Graeco-Roman cemeteries extending from 2.4 km SSW of the Tomb of Petosiris to about 2 km NW of Tuna, a stretch of 7-8 km. The whole area is a mighty necropolis, belonging to the Herm-pololite Nome and replacing the older cemeteries at El Barsha and Sheikh Said. The townsite of Tanis, immediately north of Tuna, is itself far too small to play a major role here. The tomb and mortuary temple of Petosiris was constructed after c. 340 and completed before c. 300 B. C. South of this curious architectural hybrid lies a whole mortuary city excavated by Cairo University staff members —most elaborate and exquisite, yet today in an area of blowing sand and hostile environ-ment. The various houses or tombs associated with this city are all younger than that of Petosiris, and date into the first half of the 2. century A. D. There are remains of wells, saqiyas, ponds, palm gardens as well as houses notable for every detail of luxuriant living — all for use on special occasions associated with the rites of the deceased. It remains imperative that the western margins of the Nile Valley in Middle Egypt were good agricultural lands in Ptolemaic and Roman times. The basic differential must be assumed to have been physical, although the rural policies of the Ptolemies may also have contributed effectively to this temporary reclaimal of some 250 to 350 square kilometers of now 'worthless' land. For the area involved see symbols *Qha* and *Qhae* of the geological map in Butzer (1959b, Fig. 1).

New and improved crops or livestock were the second key to rural expansion. The staple crop of the country, wheat, was improved by the introduction of new varieties. The cultivation of the vine and olive were fostered and protected by heavy duties. Instead of supplying fruit they were made into wine and olive-oil, particularly in the areas of Greek rural settlement. J. A. Wilson (1955) reviewed the major wine regions of Egypt, and Strabo (XVII. 1. 35) mentions that olives are produced almost exclusively in the Fayum. Vegetables crops and fruit trees were improved in various ways. A new species of sheep providing better wool, possibly a new species of pig were introduced; the camel was put into effective transport use. There is also evidence that pines were extensively planted for ornamentation and to relieve the chronic deficiency of timber.

Thus ample evidence is available, that coupled with a sound economic policy and a carefully controlled system of tax-farming, the earlier years of the Ptolemaic dynasty were a period of exceptional social stability, rural expansion and general prosperity. For a full century there were no foreign invaders or local unrest. Urban industry flourished, particularly linen, glass and stone-work were produced in Upper Egypt. Commerce was strongly championed by the Dynasty, both export and import, as well as the transit trade via the Red sea ports and the Nile Valley. There seems to be no need to expand on the architectural accomplishments of the Dynasty : apart from innumerable additions, restorations etc. the notable temples of Dandara, Deir el Madina at Qurna, Esna, Edfu, Kom Ombo and Philae, begun by Euergetes and his successors and generally completed but for details before the Roman conquest.

Strabo's Geography of Egypt.

None of the classical geographers rival the Pontic-born Greek Strabo in objectivity, balanced presentation, interpretation and historical depth. And Strabo's Geography of Egypt is his finest work, it is a classic *Landes-kunde* that cannot be compared with the mythic concoctions of Egyptian history and exotic miscellanea compiled by other classical authors. Strabo visited the Nile Valley up to Philae in 25-24 B. C., and did not

complete his written narrative, particularly book XVII, before A. D. 19, shortly before his death. In Strabo's day the golden years of the Ptolemies lay some two centuries back and the populace even seems to have temporarily appreciated the restoration of public order after the conquest by Octavian (Augustus) in 30 B. C.

Encouraged by the successful participation of native Egyptian troops at the Battle of Raphia in 217 a national rising, destined to be the first of many, had broken out in Upper Egypt during the late 3 century B. C. With the decline of the dynasty came inflation, shrinkage of the revenue, tax extortions, misgovernment and unrest. By the close of the reign of Philometer in 145 B. C. economic distress and administrative disintegration were widespread and obvious. The remaining century was one of repeated wars directed against national risings in Upper Egypt.

Rostovtzeff (1941, p. 910 ff.) considers the resentment, non-cooperation and hostility of the Egyptian labouring classes as the major reason for economic decline. This attitude had been evoked through economic oppression of the working classes, and the various effects of a division of the populace into two groups, one of which was economically and socially privileged and consisted to a large extent of foreigners. The resulting discontent and repeated rebellion led to the disintegration of the monarchy more decisively than any weakness or disability on the part of the Ptolemies.

Consequently the picture that Strabo gives of Egypt has a considerably altered complexion. His descriptions of the various towns and cities are brief but single out the salient characteristics at the time. Alexandria, which had replaced Memphis as capital during the earlier years of Ptolemy I, had grown to be the greatest commercial center of the inhabited world, although Strabo adds that the last century of Ptolemaic disorder had led to a decline in prosperity (XVII. 1. 12-13). Turning to the other leading cities described, Strabo mentions that Memphis was large and populous, second only to the capital. Like Alexandria its population consisted of mixed ethnic groups. Although the temples of Ptah, Apis and of Aphrodite still adorned the city, the old palaces were in ruins and abandoned (XVII. 1. 31-33). Further upstream Ptolemais is called the largest city of Upper Egypt, not being appreciably smaller than

Memphis. Strabo mentions that its civic institutions were modelled on those of the Greeks (XVII. 1. 42). Coptos appears to have been the second largest. Strabo stresses its commercial significance as emporium for Red Sea commerce. The population consisted in part of Egyptians, in part of the Bidscharin (« Arabians»). The prosperity was due to the road constructed by Philadelphus to Berenice : deep wells had been dug and cisterns set up for the occasional downpours (XVII. 1. 44-45). Thebes strikes a rather pathetic note, the « city of the hundred gates» had once been the largest of all Egypt but had then been reduced to a « collection of villages» squatting among the bygone splendour. The contemporary town site extended on both banks of the river, the only notable monuments that struck the geographer were the obelisks, the Memnon colossi and the tombs of the Kings. Strabo accepted the misleading tradition that Cambyses was responsible for the destruction of the city (XVII. I. 46). Actually this process was more complicated : the wealth of the city disappeared with the thorough sack of the Assyrian Asarhaddon in 672, repeated by Assurbanipal 667. Then came various Egyptian revolts which were mainly centered at Thebes, so it appears that independent native pharaohs ruled there for 19 years during the reign of Philopator (221-203). The city suffered much, the climax was reached in a three-year siege and almost total destruction by Ptolemy XIII Auletes in 85 B. C. The rest was done by a number of serious earthquakes, particularly in 27 B. C.

The other towns of the Nile Valley are discussed considerably more summarily. A number are simply mentioned by name, so Cercesura (Warraq), Babylon (Old Cairo), Troia (Tura), Tanis (Tuna el-Gabal), Lycopolis, Aphroditopolis, Diospolis parva, Crocodilopolis (el Tod), Aphroditopolis (Gabalein), Ilithyiaspolis, Hierakonpolis (Muessat) and Syene (Aswan). Several others are mentioned in connection with some oddity such as a special cult or temple, so Acanthus (el Nakanda), Arsinoe, Heracleopolis, Cynopolis, Oxyrhynchus, Hermopolis, Tentyra, Hermonthis (Armant), Latopolis (Esna), Appollonopolis and Elephantine. The remarks on a few of the remaining towns are often interesting. So Heliopolis, which had been a noted center of priestly learning in the days of Plato and Eudoxus, was entirely deserted and in a state of ruin. The

temples and obelisks had been severely damaged, for which Strabo (XVII. 1. 27-29), unjustly, blamed Cambyses. Panopolis is described as an old settlement of linen-workers and stone-workers (XVII. 1. 41), suggesting that these two industries were rather significant in the area, just as the Egyptian metal industry had traditionally been centred at Memphis. Strabo (XVII. 1. 42) notes the decline of Abydos from a large city « second only to Thebes», to a village. One may recall that Soter shifted the nome *metropolis* from Abydos to Ptolemais, this may have been a major reason for, or it may have simply reflected the earlier deterioration of the site. The comments on Philae (XVII. 1. 49) indicate the town as an entrepot for trade with Nubia and the Sudan, with a population of both Egyptians and Ethiopians.

At the time the country was weakly garrisoned—a generation later even more so—by only three legions with acessory cavalry based at Alexandria, Babylon and Syene (XVII. 1. 12, 30, 53).

The remainder of the text describes the elements of the vegetation (carob and date palms, sycomore fig, acacia, persea), the fact that papyrus was already confined to the lower Delta and the Maryut, various agricultural crops, particularly in connection with the fertility of the Fayum. Here wine, olive-oil, grain, pulse and other seed-crops were produced in large quantities (XVII. I. 35).

Apart from his vivid geographical description he presents a shrewd analysis of the economic decline under the Ptolemaic epigones, coupled with interesting remarks on the character and customs of the populace, and on the Nile and its sources.

Settlement Patterns and Symptoms of Economic Decline during the Period of Roman Dominion.

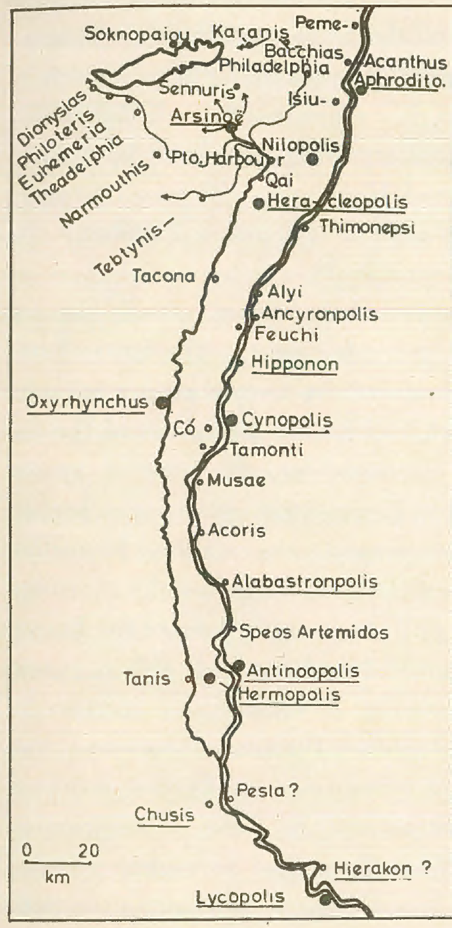
Already Herodotus, who spent over three months in Egypt about the year 450 B. C., refers to some ten cities in the Nile Valley. In the succeeding Ptolemaic epoch there are occasional references to Egyptian towns by Greek philosophers and historians, but all in all the most important literary reference to existing towns is that given by the innumerable Greek papyri found mainly in the Fayum, at Oxyrhynchos

and el-Hiba. Beginning with Diodorus of Sicily there are a number of classical references extending right through to the Arab Conquest, and which have been accurately analyzed and usably presented by J. Ball (1942). Diodorus mentions 10 towns of the Nile Valley; Strabo 31; Pliny, whose *Natural History* was published c. A. D. 77 did not represent any personal knowledge of the country, 20; Ptolemy, writing about A. D. 150, 49; the *Tabula Peuteringiana* of the second or third century A. D., 23; the *Antonine Itinerary,* dating from the time of Caracalla (A. D. 211-217), 46; the list of military garrisons (*Notitia Dignitatum*) under Valentinian III (A. D. 425-455), 37; Hierocles, writing c. A. D. 535, 30, and George of Cyprus in A. D. 606, also 30. In addition to these there is a great corpus of Coptic material, presented by E. Amélineau (1893) including Coptic documents or lists dating from the mid-fifth to the mid-seventh centuriess, and Coptic-Arabic sources, including documents, the history of John of Nikion writing immediately after the conquest, and the Coptic Synaxarium—all dating from the first two or three centuries of the Arab dynasties.

On the basis of the two major references above and consultation of a broad range of original sources, also such as were not used in Ball and Amélineau, Table 2 has been drawn up. It attempts to give as complete as possible a list of towns and villages as are documented and recognizable during the period under study. Testimony from various sources is checked on the table so as to present a chronological picture or at least a guage of relative significance. The standard Greek names have been rendered where known, otherwise the Coptic. The towns have been listed from the apex of the Delta to the First Cataract in that geographical order (see Fig. 1-3), and divided into west and east banks. This list of 101 place names attempts to be as complete as possible, but obviously cannot be so as numerous minor sources are bound to have escaped the writer's notice. Such towns as were only verified in the Coptic-Arabic sources or whose location is fully unknown are not included.

In Fig. 1-3 those towns mentioned by at least one half of the above sources have been capitalized throughout or otherwise indicated, and so stand out as more important centers. The list is almost identical with

Fig. 1. *Towns and Villages of Upper Egypt in Hellenistic Times.* Leading towns are capitalized throughout, Ptolemaic-Roman nome capitals are underlined, Coptic bishoprics indicated by large closed circles.



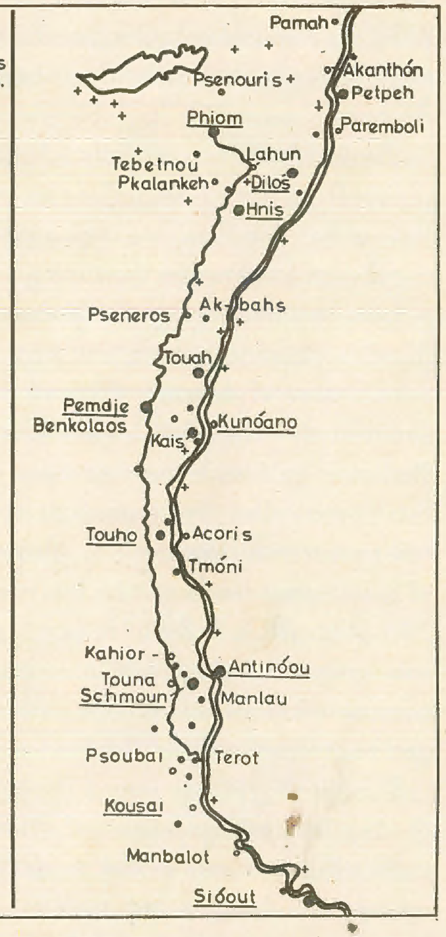


Fig. 2. (left) *Towns and Villages of Middle Egypt 4th century B. C. 3rd century A. D.* Leading towns indicated by large, closed circles, nome capitals underlined. Note main lines of irrigation-water supply in Fayum. Classical transcription of place-names.

Fig. 3. (right) *Towns and Villages of Middle Egypt 6th-8th centuries A. D.* Towns extinct since Roman times indicated by crosses. Towns verified only after A. D. 640 indicated by small, closed circles, usually without name. Bishoprics according to the Coptic lists indicated by large closed circles, bishoprics according to George of Cyprus underlined. Place-names are transliterated from the Coptic, modern names are referred to in text.

that of the nome capitals in Table 1, except for older *metropoleis,* Nilopolis, Roman additions or substitutions, Hermonthis, Antinoopolis and Antaeopolis, or towns closely associated with the nome-capitals although never attaining such rank : Babylon, Latopolis, Syene and Philae. A few of the minor *metropoleis* in Table 1 are not represented, so Ilithyiaspolis, outflanked by Esna and Edfu; Aphroditopolis (X), replaced by Antaeopolis; Hypsele; Chusis; Hebenu, and Hipponon. All in all however it is surprising how the economic unit of the nomes dominates the population patterns of the entire period.

Land tenure during the Roman period underwent certain changes despite retaining a basic similarity to earlier days. The better lands remained royal domain, although many of the temple properties were confiscated. The great estates which had mainly grown out of the the Ptolemaic gift-lands were gradually brought into the imperial private estate controlled by a procurator. The military settlements became full property of their owners. Private property was increased by auction of government lands or easy leases on marginal lands in order to extend cultivation (H. I. Bell 1948, p. 74-75). In the early years of the Roman rule irrigation schemes were rejuvenated and coupled with a strong efficient administration there was at first a considerable increase in prosperity, probably to the level of the early Ptolemaic monarchy.

However Egypt was one of the two granaries of the Empire, required to ship immense quantities of wheat annually to Rome. This one-way traffic of goods and money meant that Egypt had been reduced to a colony, not deriving any material benefits apart from administration. In fact no architectural work beyond occasional renovations or additions was carried out by the government after the reign of Tiberius (A.D. 14-37) despite its exclusive monopoly of quarrying rights. But not even efficient, honest administration was guaranteed, and serious irregularities were apparent at an early date. Taxfarming and other public functions were required as duties from the wealthier citizens. This matter of coercion was rather unfortunate as the demands were exceedingly high, and the unfortunate citizen was reponsible with person and property for all losses and deficiencies (Bell 1948. p. 78 ff.). This *liturgical* system ended by ruining the better-to-do peasantry and the middle class, particularly after the latter half of the second century. The second form of gross exploitation was in the lease of royal land. The tithes were so high that it was often impossible to find voluntary bidders, in which case coercion was applied. Bell outlines two ways in which this was done : either unlet land in one village was assigned with all responsibility to the villagers of another town, or it was attached piece-meal to private holdings, compelling the owner to come up for these taxes as well. In this manner the royal land had almost disappeared by the fourth century in the administration's efforts to keep all land under cultivation, thus keeping the tax income such as to cover ever-increasing exactions by Rome.

Cases of tenants' families being imprisoned and tortured to find a defaulting tax-payer, of whole villages or towns deserted by their inhabitants, are already known from the reigns of Caligula and Claudius (A. D. 37-54). Nevertheless there does not seems to have a notable deterioration in the standard of building before the end of the second century. In A. D. 202 senates or municipal councils were established in the nome capitals, the wealthier townsmen of which were now responsible for the financial administration. Bell (1948, p. 91 ff.) considers this the decisive step in the ruin of the hellenized bourgeoisie. After the beginning of the third century rural depopulation was a common feature. Public works, particularly irrigation canals, were not kept in order and hardship resulted. So it is known that Theadelphia had to be abandoned because of failure of the water supply in the fourth century, Karanis a century later (Boak 1946). Although population density remained high, economic distress and depopulation were universal by the beginning of the Byzantine era—on a level unknown since the beginning of Ptolemaic rule.

Settlements on the East Bank in Middle Egypt.

Perhaps no single problem of settlement is as interesting as that of why the settlement remains along the eastern banks of the Nile are so extensive in parts of Middle Egypt where there is next to no alluvium, at least today. So far two similar questions have been treated and explanations offered, e.g. the great necropolis at Tuna el-Gabal whose

temporary splendour we attributed primarily to the shifts of the Bahr Jusef, and the great density of settlement right on the desert edge—due to rural expansion to the outer limits of cultivation. The third problem raised here is in part of course related to the policy of extension of cultivation, but it is more intricate.

Already in the 18. Dynasty Akhnaton (Amenophis IV) had founded his capital at Amarna on the east bank nearly opposite Mallawi. There is next to no alluvium here and all food-supplies had to be transported across the river, so that we cannot agree with Wilson (1955) that the splendid scheme was geographically well-chosen. This curious logic of a town without a hinterland does not stand alone. One can ask the question why three nome capitals, apparently all stemming from Old Kingdom roots, are similarly located (Hebenu, Cynopolis and Hipponon). Then comes the founding of Antinoopolis in the 2. century A. D.—with less than 200 feddans of alluvium in the vicinity. Some of these towns were extremely large in comparison to towns elsewhere. Jouguet (1911, p. 205 f.) stresses the compact nature of Egyptian towns. So for example the koms of Dionysias, Bacchias and Theadelphia do not measure more than 300 by 500 meters. But on the east bank Antinoopolis, according to the *Description d'Egypte* and personal observations, exceeded 800 by 1500 meters [1], the core of Hebenu (by personal observations) about 200 by 800 m—with considerable extensions to the southeast (cf. Kaiser and Butzer, 1960). The writer has not visited the sites of Cynopolis, Hipponon or Ancyronopolis.

The question that can be asked is whether the position of the river was different at that time. We can attempt to answer it by two approaches, one of them literary. Ptolemy (cf. Müller 1901, Ball 1942, p. 101 ff.) lists many of his place names with reference to the river such as « on the east bank», « inland», « in the interior», etc. This enables us to compare whether there have been any changes of the Nile course since. The Nile, as a natural meandering river could be expected to do so—except

[1] The ruins of Arsinoe were not much smaller in 1800, yet that town had a population of 100,000 or more in Roman times. Today Sheikh Ibada, the successor of Antinoopolis, has about 2000 inhabitants.

that artificial levees have long controlled its movements, and no really significant changes have occurred since the French 1 : 100,000 maps were surveyed and compiled about 1800. *If* the following towns were actually *on* the respective banks in the 2. century one could postulate the following shifts : Memphis, Nile has shifted 3.6 km eastwards; Dallas, Nile same; Heracleopolis, Bahr Jusef same; Co (el Qeis), Nile shifted 2.5 km eastwards [1]; Acoris, Nile shifted 0.6 km westwards—something supported by the great inscription of Epiphanes (203-181 B.C. on the limestone cliff, which was obviously intended to impress passing boat-travellers; if Alabastronpolis is really Hebenu and not Hetnub, « in the interior» could signify the Nile was located somewhat to the west at this critical point; Antinoopolis, Nile same; Antaeopolis, « in the interior», leaves no doubt that the river has since shifted eastward, in fact the town was destroyed in 1821 by such a shift. The *Antonine Itinerary* lists all towns on the right side of the river, so that at least such major branchings of the Nile are excluded. This suggests that the continual misplacement of towns on the Peutinger map is simply a matter of gross inaccuracy, in fact it is physically impossible that sites like Acoris or Antinoopolis were ever separated by water from the eastern desert.

On the face of it the above evidence carries strong suggestions that considerable shifts have occurred. But for Memphis it is known that canals connected it to the Nile, in the case of Hebenu there is an ancient dam of pre-Byzantine age either representing the artificial levee along the Sawada Canal—as a more recent dam at the same locality does now—or of the Nile (Butzer 1960). If the latter were true, lateral movement would be precluded, the former however would not prove anything. That Hebenu may have been called Alabastronpolis in Ptolemy's day

[1] The case of Cynopolis (Sheikh Fadl) is uncertain : does the statement « Cynopolis, opposite Co, on the island» mean « Cynopolis—opposite Co which is on the (Heracleopolite) island» or « Cynopolis on the island». In the latter case Sheikh Fadl may possibly have had a Nile arm to its rear. The former explanation seems more convincing however.

is possible, as there are several quarries in the adjacent wadis. Also the latitude given by Ptolemy 28° 20′ N., not necessarily correct, seems too far north for Hetnub (27° 38′). Hebenu is actually at 28° 3′. Although the evidence is not conclusive, it may well be possible that there was more alluvium attached to the east bank at some localities, although not at Acoris or Antinoopolis. Such a physical factor must be considered possible however.

The idea seems more plausible yet when reviewing the Roman roads of the *Antonine Itinerary* (cf. W. Kubitschek 1933). These lists of roads and towns or relays dating from the early 3. century (Kirsten 1959) were probably compiled from more official sources. The striking fact is the continuous road along the east bank of the river from Babylon over Hipponon and Antinoopolis to Thebes and Aswan. The accuracy of the Itinerary is phenomenal so that there is no need to doubt this. Yet today there is no longer any serviceable north-south road from opposite el Wasta to opposite Manfalut. The reason for this condition is that such a road is not really necessary—there are insufficient people to make it worthwhile or to take care of the upkeep, and those villages or hamlets that do exist carry on well enough with the local ferry service. Physically such a road would also be difficult to construct, as the strip of alluvium is discontinuous and the desert terrain often rather difficult to employ for such purposes. A river situated a little further west, or meandering a little stronger would give the east bank a greater resource base, more alluvium and a greater population, and it would make the towns and roads seem somewhat more appropriate.

All of the towns of the east bank between Manfalut and Wasta are now inconsiderable and have been so since at least the 14. century. There has been very considerable depopulation of the east bank, and a shift in the larger towns from it to the west bank of the Nile.

Wholesale rural Depopulation during the Byzantine-Coptic Epoch.

Two decisive factors determined the course of economic life in the three centuries of Byzantine rule—the Christianization of Egypt, and the administrative reforms of Diocletian. The new belief was introduced

to Egypt at an early date in the 1. century, and the Christian community before the savage persecutions of the reign of Diocletian (284-305) warranted the office of three bishops. After the toleration edict of Milan in 313 the number of Christians grew astonishingly fast so that the country was predominantly Christian by A. D. 330 (Bell 1948, p. 104) and had some 20 bishoprics. Several decisive economic consequences can be indirectly attributed to this course of events.

Firstly the changes in architectural achievement. Before the reign of Constantine (323-337) it appears that the Christians did not have access to the government quarries, so that early church architecture developed on new lines, with the use of burnt and sundried brick and a plan that was essentially Byzantine in derivation (Somers Clark 1912). The Graeco-Roman period had not availed to change the basic architectural methods of Egypt in the least, and village homes were built in fully analogous ways in the 29. century B. C. as in the 19. century A. D. Coptic architecture then was an adaptation of the Basilican plan to native construction methods and a distinctive ecclesiastical ritual. Whereas « monumental» architecture had not been seriously fostered between the reigns of Tiberius and Constantine, a series of imposing churches and monastaries now arose throughout the nation, which have largely survived the vicissitudes of time. Reflecting the emphasis of the faith the buildings remained basically simple and austere in construction and ornamentation, at least where dominated by the ideals of the cenobitic movement. Simultaneously the temples of the pagan cult were destroyed, defaced or modified and adapted to Christian use.

The second tangible economic effect of the new religion was a revival of Egyptian national life. Much has been written already of the process where by the revived native idiom and the new Coptic script became the tools of a new phase of literature giving vent to the Egyptian populace after six centuries of silence, and in which « the very soul of Egypt found unfettered expression». Already the suppression of the Christian philosophical currents by the Patriarch Cyril (A. D. 412-444) set the course for the future national, particularist and ultimately provincial character of the Egyptian Church (Bell 1948, p. 112-116). The permanent schism after the Council of Chalcedon in 451 began the unhappy

centuries of opposition against the Byzantine government, that brought unprecedented anarchy, ruin and bloodshed to the country.

The third indirect impact of the new religion was its acceleration of the process of rural depopulation. Marginal lands had begun to go out of cultivation in the 3. century, and in the Fayum the process of depopulation whereby almost all of the land won by the Ptolemies had been abandoned—until modern times—was completed by the end of the 4. century. The effects of a crushing taxation were accentuated by several symptoms of the change in religion. By the edict of Theodosius in 389 the pagan temples were ordered closed, a fact which unleashed a period of violent and bloody excesses whereby temples were looted, destroyed or annexed, pagan villages or quarters molested, destroyed, or annihilated. This was particularly the case during the office of the patriarch Theophilus (384-412). The biography of the monk Shenudi calmly relates schocking tales of destruction and murder of pagan communities in the Akhmim area. The process of rural depopulation was secondly accelerated by the monastic movement of the Egyptian anchorites. The cenobitic rule of Pakhomius (292-346) was not universal and a century later there were tens of thousands of often uninstructed and illiterate monks collected in a number of monastic centers. This withdrawal from active life of masses of exceptionally vigorous young men could only be of serious economic implication (Bell 1948, p. 109-112). From the *Paradise of the Holy Fathers* it appears that Oxcyrhynchos and its environs harboured 10,000 monks, 20,000 nuns and a secular population of less than 20,000 in the 4. century. The third agency favouring rural depopulation has been alluded to already, namely the religious and national strife of 6. and 7. centuries. After 451 the whole monophysite church stood in open dissent with the Byzantine administration, secular and religious. Off and on there were bloody persecutions by the government, retaliations by the Copts, or devastating conflicts between warring factions in the Church. Particularly bloody was the persecution of 537-570 and the internal warfare of 566-577 (J. Maspero 1923).

Although considerable changes in land tenure policy heralded the administrative reforms of Diocletian and Constantine, these were unable to halt the economic decline of Egypt or of the Empire as a whole. The introduction of a form of professional regulation quite generally bound everyone to his profession which was inherited from father to son—the so-called Byzantine servile state. Simultaneously the pressure of taxation effected a new trend in the rural picture, namely the creation of the large estates. Small owners, in order to avoid ruin, could surrender their land to a powerful neighbour. Thereafter they would be tenants bound by certain obligations in return for protection. They had so become *serfs*. By the 6. century the land was predominantly in the hands of such patrons, and divided into locally autonomous latifundia. The free cultivators, bound to the soil, did not have an easy time under the pressure of the patrons and their private 'troops'. The mass of the rural population had been reduced to a lowly class of voiceless, miserable serfs, almost a class of untouchables (Bell 1948, p. 117-126). The Byzantine period was not a happy one and it probably marked the lowest ebb in the social status of the fellahin. The Persian occupation of A. D. 616-628 was viewed with general approval, and the Arabs were acclaimed as liberators little more than a decade later.

Changes in Urban Patterns by the Time of the Arab Conquest.

The economic background and symptoms of rural depopulation have been outlined in considerable detail already, and it remains to consider the final changes in urban patterns. Apart from the great bulk of rural villages, probably differing but inconsiderably from such villages of the last century, there were still a number of larger towns or cities in which urban life was carried on. They performed an administrative function and generally harboured the bishoprics as well. Admittedly the wealthier, hellenized middle classes had been all but eliminated long before the 7. century. Yet Greek authors were still read and some rather pathetic attempts at a form of cultural life were kept up. Generally literacy was very low and even the bishops had but an imperfect knowledge of the administrative language, Greek. The leading citizens of the towns belonged to the new landed class of patrons who were predominantly of Egyptian stock.

There is little to guage the population of the cities by, but it must have been considerably smaller than it had been in Graeco-Roman times. In the 3. century the nome capitals had still had extravagant schemes of town-planning. In the Byzantine era the general picture was one of decay, a decay persisting into the Mameluke period when many of the old centres had fallen into complete oblivion and the administrative centres had as often as not shifted to new upcoming villages, unknown or insignificant in Roman times.

The basic cause for the shift of urban centers, already obvious in the Coptic era and dominant in Islamic times, lay in the administrative reform of Diocletian, a law posthumously put into effect between 307 and 310. By it the final step to full municipalization was taken : the nomes, and the nome administrations were abolished. Egypt was transformed from a complex of nomes, each with its *metropolis* and administered by a *strategos,* to a complex of self-governing municipalities (*civitates*), each with its own rural area (*territorium*) (Bell 1948, p. 101). This rural area, which broadly corresponded to that of the nomes, was subdivided into cantons (*pagi*), possessing considerable administrative importance. Thus the exclusiveness of the nome capital had been broken and a free urban development following economic and resource lines ensued. The result can be seen in a list of major towns from the 7. century, namely the bishoprics. The two lists are derived from Byzantine and from Coptic sources, which show a broad resemblance. The former are taken from the account of George of Cyprus dating from c. 606, as interpreted by Ball (and Murray) (1942). The latter is derived from the various Coptic-Arabic lists published in the original language by Amélineau (1893, p. 555-570).

The bishoprics so outlined in Tables 3 and 4 represent the major towns of Egypt as one can interpret from the almost total coincidence between the leading towns listed by Hierocles in 535 and the bishoprics listed by George of Cyprus. The Diocletianupolis of George is a little known designation as can be seen from the Coptic lists which equate *Diokletianou = Tibaki Kos Barbir*. The disresemblance between the list of nome capitals or the leading towns of Table 2 and our list of bishoprics is considerable. There are already 4 new names on the list of George,

TABLE 2

Towns of the Nile Valley and the Fayum Evidenced During Ptolemaic, Roman and Byzantine Times

A. The Western Bank

	Herodotus	Ptolemaic Records	Diodorus	Strabo	Plinius	Claudius Ptolemy	Peutinger Map	Antonine Itinerary	Notitia Dignitatum	Hierocles	Coptic Sources	George of Cyprus	Coptic-Arabic Sources
Letopolis (Ausim)						X	X	X		X	X	X	X
Cercasorus (Warraq)	X			X									
Tipersis (Giza)											X		X
Busiris (Abu Sir)					X								
Memphis (Mit Riheina)	X	X	X	X	X	X	X	X	X	X	X	X	X
Peme (Bamha)							X	X					X
Acanthon (Nakanda, former village)				X		X					X		
Isiu (Meidum)								X					
Ptolemais Harbour (Lahun)		X				X	X						X
Nilopolis (Dallas)		X	X			X				X	X	X	X
Caene (Qai)								X					
Heracleopolis magna (Ihnasiya)		X		X	X	X	X			X	X	X	X
Tacona (near Muzura)								X					
Pseneros (Shinara)											X		X
Feuchi (el Fant?)							X						
Oxyrhynchus (Bahnasa)		X		X		X		X		X	X	X	X
Ibiu(?)								X			X		
Benkolaos (Galf)											X		X
Co (el Qeis)						X					X		X
Tamonti (Mataï?)							X						
Theodosiopolis (Taha)											X	X	X
Kahior (Hor)											X		
Hermopolis magna (Ashmunein)	X	X			X	X		X	X	X	X	X	X
Tanis (Tuna)				X									X
Psoubai (Saw)											X		
Chusis (Qusiya)		X						X	X	X		X	X
Manbalot (Manfalut)											X		
Lycopolis (Asyut)		X		X	X	X	X	X	X	X	X	X	X
Hypsele (Shutb)						X				X	X	X	X
Sebhet (Sidfa)		X									X		
Apollonos micra (Kom Isfaht)								X		X	X	X	
Aphroditopolis (Kom Ishqaw)					X	X							
Tama (Tamma)											X		X
Ptolemais Hermiu (Manshah)		X		X	X	X		X		X	X	X	X
Abydos (El Araba el Madfuna)		X		X	X	X		X	X		X		X
Bersout (Farshut)											X		X
Diospolis parva (Hiw)					X	X		X	X		X		X
Tentyra (Dandara)		X		X	X	X	X	X	X	X	X	X	X
Pampanis (opposite Luxor)						X		X	X				
Hermonthis (Armant)		X		X		X			X		X	X	X
Aphroditopolis (Gabalein)		X		X		X							
Asfynis (Asfun)									X				X
Latopolis (Esna)		X		X		X	X		X	X	X	X	X
Hierakonpolis (Muessat)				X									
Apollonopolis magna (Edfu)		X		X	X			X	X	X	X	X	X
Contra Ombos (Rafaba)								X					
Parembole (Dabud)		X						X	X				

B. The Fayum

	Herodotus	Ptolemaic Records	Diodorus	Strabo	Plinius	Claudius Ptolemy	Peutinger Map	Antonine Itinerary	Notitia Dignitatum	Hierocles	Coptic Sources	George of Cyprus	Coptic-Arabic Sources
Bacchias (Kom el Asl)		X				X							
Karanis (Kom Aushim)		X											
Narmouthis (Madinet Madi)		X							X				
Soknopaiou Nesos (Madinet Dimai)		X											
Euhemeria (Qasr el Banat)		X											
Dionysias (Qasr Qarun)		X				X			X				
Philoteris (Madinet Walfa)		X											
Theadelphia (Kharabat Ihrit)		X											
Tebtynis (Umm el Baragat)		X											
Pkalankeh (Qalamshah)											X		X
Tebetnou (Difinnu)											X		X
Arsinoe (Madinet Fayum)	X	X	X	X	X	X				X	X	X	X
Sinnuris		X											X
Philadelphia (Kom el Kharaba)		X									X		

C. The East Bank

	Herodotus	Ptolemaic Records	Diodorus	Strabo	Plinius	Claudius Ptolemy	Peutinger Map	Antonine Itinerary	Notitia Dignitatum	Hierocles	Coptic Sources	George of Cyprus	Coptic-Arabic Sources
Heliopolis (el Matariya)	X	X	X	X	X	X		X		X	X	X	X
Babylon (Fustat)			X	X		X		X	X		X		X
Troia (Tura)			X	X							X		
Scenas Mandras (Tell el Minya)		X						X	X				
Aphroditopolis (Atfih)		X		X		X		X	X	X	X	X	X
Paremboli (el Burumbul)											X		
Thimonepsi (Tell el Asfar)								X	X				
Alyi (opposite Geziret el Wahliya)								X	X				
Ancyronpolis (Hiba)		X				X							
Hipponon (Ezbet Qarara)								X	X				
(Kome el Ahmar Sawaris)		X											
Cynopolis (Sheikh Fadl)		X		X	X	X				X	X	X	
Musae (el Siririya)								X	X				
Akoris (Tihna el Gabal)		X					X				X		
Alabastronpolis (Kom el Ahmar)					X	X							
Speos Artemidos (Beni Hassan)								X	X				
Antinoopolis (Sheikh Ibada)						X	X	X		X	X	X	X
Pesla (? Near el Quseir)								X	X				
Hierakon (? el Atawla)								X					
Isiu (? el Matmar)								X	X				
Muthis (? Nag Wisa)								X	X				
Antaeopolis (Qaw el Kebir)			X			X		X		X	X	X	X
Passalus (? Near el Galawiya)						X		?					
Panopolis (Akhmim)	X	X		X	X	X	X	X		X	X	X	X
Thomu (el Isawiya sharq)								X					
Lepidotonpolis (Naq el Mashayikh)						X							
Chenoboscia (el Qasr wa el Saiyed)						X	X	X	X		X		X
Caenepolis (Qena)						X							
Coptos (Quft)		X		X	X	X	X	X	X	X	X	X	X
Apollinopolis parva (Qus)				X		X		X			X	X	X
Thebes (Luxor)	X	X	X	X	X	X	X	X	X	X	X	X	X
Tuphium (el Tod)		X		X		X							X
Contra Lato (el Hilla)								X	X				
Ilithyiaspolis (el Kab)		X		X	X	X				?			
Tumuis (near Silwa Bahari?)						X		X					
Silsili (Silsilah)		X							X				
Ombos (Kom Ombo)		X				X	X	X	X	X	X	X	X
Syene (Aswan)	X	X		X	X	X	Ẋ	X	X		X		X
Elphantine	X	X	X	X		X			X		X		
Philae		X	X	X				X	X	X		X	X

Table 3

The Dioceses of the Nile Valley according to George of Cyprus c. A. D. 606

West Bank	*East Bank*
Letopolis (Ausim)	Heliopolis (Matariya)
Memphis (Mit Riheina)	Aphroditopolis (Atfih)
Arsinoe (Medinet el Fayum)	Cynopolis (Sheikh Ibada)
Nilopolis (Dallas)	Antinoopolis (Qaw el Kebir)
Heracleopolis (Ihnasiya)	Panopolis (Akhmim)
Oxyrhynchus (Bahnasa)	Maximianupolis (?)
Theodosiopolis (Taha el Aʿmida)	Coptos (Quft)
Hermopolis magna (Ashmunein)	Diocletianupolis (Qus)
Chusis (Qusiya)	Diospolis magna (Luxor)
Lycopolis (Asyut)	Ombi (Kom Ombo)
Hypsele (Shutb)	Philae
Apollonos minor (Kom Isfaht?)	
Ptolemais Hermiu (Manshah)	
Tentyra (Dandara)	
Hermonthis (Armant)	
Latopolis (Esna)	
Apollonòpolis magna (Edfu)	

Table 4

The Dioceses of the Nile Valley according to the Coptic

Lists of the 7th Century

West Bank	*East Bank*
Bouschim (Ausim)	On (Matariya)
Tipersis (Giza)	Petpeh (Atfih)
Memphis (Mit Riheina)	Kunóanó (Sheikh Fadl)
Phiom (Medinet el Fayum)	Antinóou-Poufisa (Sheikh Ibada)
Dilos (Dallas)	Tkóou (Qaw el-Kebir)
Hnis (Ihnasiya)	Schmin (Akhmim)
Toubah (Tuah)	Hou (Hiw)
Pemdje (Bahnasa)	Kepht (Quft)
Touho (Taha el Aʿmida)	Kós Berbir (Qus)
Schmoun (Ashmunein)	Embó (Kom ombo)
Sióout (Asyut)	Souan (Aswan)
Schótep (Shutb)	
Sebhet (Sidfa)	
Aksenkeuson Tinischti (Kom Isfaht?)	
Nitentóri (Dandara)	
Ermont (Armant)	
Isni (Esna)	
Atbó (Edfu)	

3 further new names in the Coptic lists. 21 % of the towns on these Coptic lists were never nome capitals, and are not included among the leading towns of the Graeco-Roman period. This appearance of new towns becomes more obvious when the towns known from Coptic sources and Coptic-Arabic sources are compared with those known from classical sources dating from before the end of the 3. century. Fig. 2 and 3 show this distinction for Middle Egypt including the Fayum.

Of the 40 middle Egyptian towns known in Graeco-Roman times, 24 (60 %) have disappeared from record. As our knowledge of Coptic place names is far more complete than that of any previous period, due to the amount of literary evidence, it is reasonably certain that these had either been abandoned or had sunken into insignificance. Of these 24 towns 19 are on the margins of cultivation (10 on the banks of the Fayum, 9 on the east bank), indicating rural depopulation in the Fayum and on the east bank. The appearance of at least 31 new towns in the Coptic-Arabic period need not be alarming, and they mainly represent villages existing but not recorded previously because of incomplete evidence for the earlier period. They do however contain several centers which have become rather important in modern times : Tmóni (el Minya), Manlau (Mallawi), Terot Saraban (Deirut es-Sherif) and Manabalot (Manfalut). All in all both periods contrasted here have only 18 % of their 71 towns and villages in common, a fact which underscores the considerable changes in settlement patterns between Greek and Coptic-Arabic times. The underlying reasons are two-fold : depopulation of the marginal lands temporarily occupied in the Graeco-Roman period, and the appearance of new towns in better resource locations between the Nile and the Bahr Jusef, made possible by the disappearance of the nomes as strict economic units. Minya replaced Hebenu; el Qeis (Kais) replaced Sheikh Fadl; Toubah (disappeared since the French Survey) and later Maghagha replaced Hipponon; el Aqbahs and later el Fashn replaced Ancyronpolis.

A third change in pattern occurred in early Islamic times when depopulation took place along the Bahr Jusef stretch, most probably due to physical factors. So Oxyrhynchus (Bahnasa) and Tanis (Tuna) were no longer listed in the catastral survey of A. D. 1315. On the east bank

Antinoopolis had also sunken into oblivion. And in the same period Cairo fully replaced Memphis, which name had also been lost by 1315.

The 1000 year span of the Hellenistic age, in the broader sense of the word, was a remarkable period of transition in Egypt. In the Coptic period one can unmistakably observe the modern patterns emerge. Even the place names of the Coptic era are often almost identical with those of to-day, indicating the ancient Egyptian toponyms have generally survived both the Greek and the Arabic.

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NEW LIGHT ON THE ORIGIN OF THE QATTARA DEPRESSION

BY

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ABSTRACT

Evidence obtained from a study of the areal distribution of the Miocene rocks of the Western Desert in which the Qattara depression is excavated shows that this depression is an erosive feature due primarily to wind action as suggested by Ball (1927). The removal of the upper limestone cap of the Miocene sedimentary column is due to solution under wetter but still desert climatic conditions that prevailed over Egypt since the Middle Miocene time. The growth of the depression is from south to north starting at the cuesta formed at the formational boundary between the Miocene and older rocks (Pfannenstiel, 1953). The present day topography of the depression is governed by the thickness of the limestone cap of the Marmarican formation. Thus the promontory between Qattara and Siwa having a thick limestone section failed to retreat as fast as the eastern extremity of the depression where the Marmarican formation is thin.

The Qattara depression first discovered and mapped by Ball (1927, 1933) forms one of the most significant morphological features of the northern Western Desert of Egypt. The depression is bounded from the north and west by steep escarpments the top of which averages in elevation about 200 m above sea level. Towards the south and east the floor of the depression rises gradually in the general desert level. It is difficult, therefore, to specify the extent of the depression in the last named

directions although it is usually regarded as being bounded by the zero contour. Thus delimited the depression has an area of some 19,500 km^2 and an average depth of -60 m. The lowest point in the depression is -134 m which lies at the south-western part of the depression. The capacity of the depression below the zero contour is 1167 km^3.

Because of the fact that this depression is a closed inland basin with no access to the sea, it was and still regarded as a text-book example demonstrating the effect of deflation over arid regions. All authorities seem to agree in one way or another to Ball's contention (1927) that this depression is the result of wind action and that the depth of its floor is governed by the ground water table which forms in a way a base-level for wind action. Large quantities of the sandy constituents of the Miocene formations in which the depression itself is hollowed and which are exposed in the northern and western escarpments have been blown by wind south-south-eastwards and deposited in the form of great lines of sand-dunes, some of which are to be seen in the most southerly part of the depression itself, while others stretch for long distances over the desert beyond it.

Ibrahim (1952) differed, however, with other workers on the subject in excluding the erosive action of wind due to repulsion among the grains explained as a result of their «electrical charge». This, according to Ibrahim, would reduce immensely «the impact of the driven grains in sand storms». Ibrahim claims that the origin of depressions is tectonic. Basins thus formed will develop an internal drainage, the waters of which will find their way to depths in cracks and fissures that will result from the shattering of the basins. The decay of rock by bacterial action and solution would cause the development of residual deposits that can be driven away by wind. Wind, would then transport material to the low-lying depressions. Even though both processes may occur simultaneously, «depressions may still exist, or even get larger in time if other factors of rock decay—are dominant».

Pfannenstiel (1953) reviewed critically earlier literature and came to the conclusion that neither an explanation by tectonic subsidence nor by wind erosion nor by aquatic scouring can account for the origin of these depressions. He believed that depressions form next to formational

(geological) boundaries due to the development of cuesta landscape. Thus steeper dipping formations show a narrow spacing of cuestas while nearly horizontal sequences display a wider spacing. Consequently the depressions are deeper and more spaced in the north than in the south.

Knetsch and Yallouze (1955) commented on Pfannenstiel's work and added the remark that depressions lie along boundaries of structural facies, their origin being intimately connected with tectonic deformation and fractures that cause open and easier way for exogene scouring and deepening.

The following paper is concerned only with the origin and evolution of the Qattara depression. This depression is unique in being the largest and deepest of depressions and in having a well marked and steep northern and western walls. It differs also in being excavated in the almost horizontal Miocene sediments which form a blanket deposit that covers an uneven erosional subsurface.

The Miocene sediments in which the depression is excavated, have been the subject of an intensive lithostratigraphic as well as biostratigraphic study (Said, MS). According to this work the Miocene sediments of the Western Desert of Egypt are formed of two distinct rock units : an upper limestone unit, the Marmarican Limestone Formation and a lower clastic unit, the Moghra Formation. The Moghra Formation is a distinct rock unit that can be traced in the field for long distances particularly along the Qattara northern scrap. It is typically developed to the north of Moghra oasis where it forms a thick sand-silt unit with a mixed fluvio-marine fauna. Towards the west, approximately west of Long. 27° 30′ E it becomes more shaly, thinner and contains, an open bay shallow foraminiferal assemblage.

Towards the north along the Mediterranean coast, the Moghra Formation can be traced in the subsurface as a thick unit where it loses its characteristic lithological identity being formed, at least in the west, by marls and sandy limestones of an open marine facies.

The overlying Marmarican Limestone unit is a blanket deposit which is uniform in lithological and biological characteristics for long distances. It is formed of reefal neritic limestones that become gradually sandy approximately to the east of the Longitude of Alamein. This unit thins

regionally towards the east being represented only by a few meters of sandy limestones in Moghra.

The whole Marmarican plateau in which the Qattara depression is excavated shows no evidence of tectonic deformation. A minor regional uplift took place immediately in post-Miocene time bringing the starta to dip unnoticeably to the north and to the west (10′ to 12′). This uplift seems to have not been accompanied by any significant tensional stresses. Except for a few faults of a Mediterranean trend in the north of the plateau, there are hardly any faults that cross the region which lie almost flat and undisturbed. Recent drilling in the depression itself (e. g. Ghazalat and Betty wells as well as a large number of shot hole points and water wells) excludes any possibility of the presence of faulting along the Qattara scarp for these wells pass into the clastics of the Moghra Formation, which are surely the downward continuation of the beds exposed in the surface. The Qattara wall is proved, therefore, conclusively and beyond any doubt, to be an erosional feature.

An examination of the accompanying map exludes the possibility of a tectonic origin for the Qattara depression. There is no indication of a shattered basin as concluded by Ibrahim (1952) and there is no proof that the position of the depression is connected with a particular structural facies as suggested by Knetsch and Yallouze (1955). Even though the pre-Miocene history of Qattara and Marmarica is complex and is intimately connected with the mobile shelf tectonic history, the excavation of the depression itself is in a blanket deposit that reflects little if any of the covered basinal history of the area. The fact that the Qattara depression was not excavated in a region that is tectonically deformed clearly indicates that this depression is a feature due to erosion. Ball (1927) was also of this opinion but he noted that although wind would account for the removal of the soft underlying Moghra sands and silts, he could not give an explanation for the removal of the hard limestone cap rock.

The enclosed map which was prepared from aerial photographs gives a possible mechanism for the removal of this rock. The Marmarican plateau is seen littered with minor depressions (shaded on the enclosed map) that seem to shed light on the origin of the great Qattara depression.

These minor depressions seem to represent an embryonic stage in the development of the greater depression. The mode of formation of these minor depressions can best be explained as due to deflation of residual materials caused by solution and rock decay in a manner that was suggested by Ibrahim (1952). The fact that there is a preferred direction for these depressions, most of which have north-south direction, may suggest that these depressions got their inception as a result of a linear pattern in the rock. Some kind of jointing produced these linear topographic lows that were filled ephemerally by water that soon evaporated under desert climatic conditions that have prevailed over Egypt in post-Miocene time. Some percolation of this water beneath must have occured but this must have been very little indeed for the non-porous nature of the Marmarican Limestone has been noted for a long time, so much so that the Romans excavated chambers in it to form reservoirs, of which many hundreds still exist.

Once these depressions reach a depth where lateral cutting becomes easier than downcutting, they grow laterally to coalesce forming larger depressions. The Marmarican plateau shown in the accompanying map has many of these coalescing depressions. As this process continues, large stretches of the limestone formation would degrade. Such a stretch could be seen in the area immediately to the north of Ghazalat where a large surface is seen levelled to the hard dark grey limestone bed that forms a distinctive ledge at the base of the Marmarican Limestone Formation. This new surface will again be lowered by the same processes. Once the limestone cap is removed the underlying free running sands of the Moghra Formation would fall under processes of mass-wasting to be deflated away. Thus the depression is shown to have grown northwards.

The point of origin of the Qattara depression is connected, as Pfannenstiel (1953) has suggested, with the development of a cuesta at the formational boundary between the southernmost extension of the Marmarican Limestone Formation that must have lain above the exhumed surface of the depression, and older rocks. The fact that the Marmarican Formation thins regionally southwards and eastwards explains the position of the depression and its present shape and topography.

It is difficult at present to project even in an approximate way the southern extension of the Marmarican Formation. A reasonable limit is that of Latitude 29° N for no where south of this latitude can this formation be seen. It is almost certain that the beds of this formation continued to have a northern dip for at least the Latitude of Fayum. This can be deduced from the fact that the exposed Lower Miocene deposits to the north of Birket Qarun have this dip. Such a situation would bring about a reconstruction of the original land surface in which the depression was eroded, that would necessitate the removal of no less than 20,000 km^3 of material to account for the present day topography. A fraction of this figure would account for a ready source for all the drifting sand in the Egyptian Western Desert. It is interesting to note that mineralogically the sand dunes of the Libyan Desert as determined by White (1935) are very similar indeed to that of the Miocene sediments of Egypt as determined by Shukri and Ayouty (1954).

CONCLUSION

1. Evidence obtained from a study of the lithology and attitude of the Miocene strata in which the Qattara depression has been excavated shows that this depression is primarily an erosional feature whose origin may be sought in a process that combines the various forces suggested by previous authors.

2. Tectonics played a minor role if any in the formation of the depression. No faults bound any of the morphological features of the depression or cross it. Boreholes drilled in the bottom of the depression show no repitition or reversal in the order of strata. Furthermore, the depression, being cut in a blanket deposit, shows that its evolution was not connected with any particular structural facies.

3. The position and present-day topography of this depression is governed primarily by the distribution and thickness variations of the two lithological units that build the elevated bed in which this depression was excavated. The north-east south-west trend of the northern Qattara wall is due to a faster retreat in the eastern side of the depression where the top hard limestone beds of the Marmarican Formation are thin. Indeed the promontory that separates the Qattara and Siwa depressions is marked by the thickest section of the Marmarican Limestone.

4. The depression is assumed to have grown from the south northwards. The original cuesta formed to the south along the formational boundary of the Miocene limestone and older clastics has consistently retreated to the north keeping most probably the original angle of slope, to occupy finally the present-day Qattara wall. This process of parallel retreat of slopes is accomplished by active wind erosion on both the slopes and the mass-wasted heaved surfaces.

5. The removal of the hard top limestone layer that caps the free-running sand beds is best studied by an inspection of the present day topographic features of the Marmarican plateau (Figure 1). Here north-south joints are degraded first by solution and then by wind to a temporary base-level determined by the hard layers that intercalate the succession followed by lateral retreat of the sides. When several of these depressions coalesce an exhumed erosion surface is produced which would then be removed in the same manner until the underlying column of free running clastics is uncovered. This, upon mass wasting, would be eroded away by wind.

6. The depth of the depression is limited by the ground water level, forming in a way an ultimate base-level for wind erosion in basins of the arid zones.

7. A chronological table of events is impossible to reconstruct (compare Pfannenstiel, 1953). Judging from the volume of material removed and the stratigraphic relations, the formation of the depression must be assumed to have started at least immediately after uplift in post Middle Miocene time in a process that must have continued to this day. Arid climatic conditions are necessary for the development of this depression although the frequency of rain must have been greater than to-day. Rainfall of the Pleistocene fluvial phases was ineffective in producing drainage lines or vegetative cover. Ephemeral lagoons may have been formed during these phases which helped about the solution of the rock and its decay, but a little part of the waters must be assumed to have penetrated deep into the rock to form a reservoir that feeds, till to-day,

the numerous springs along the Qattara scarp. The presence of an intensive mass of salt rock exposed in the bottom of the depression attests to the fact that arid climatic conditions must have lasted for a great length of time as recently suggested by Murray (1952).

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Fig. 1. Map of part of the Marmarican plateau to the north of the Qattara depression showing the extent of its lowering and retreat.

CERTAIN ASPECTS OF LANDFORM EFFECTS ON PLANT WATER RESOURCES

BY

M. KASSAS

INTRODUCTION

The features of the climate, as recorded at meteorological stations, are the causative factors in determining the features of the desert environment. The aridity, which characterises the desert, is the result of low rainfall associated with intense evaporation. But when we come to deal with the plant growth of a certain area we soon realise that the climate is radically modified by the landform; and that the climatic features involved in the intimate relationship between the plant and its habitat are different from the data of the meteorological stations. The features of the landform may modify the water revenue *per se* or may modify the intensity of water loss by reducing the temperature or increasing the atmospheric humidity. In this paper we shall mention a number of examples of landform effects on plant water relationships*.

RED SEA COASTAL HILLS

In this example we shall briefly describe a 70 km. (*c.* 43 miles), transect cutting across the Red Sea Hills form Suakin to Sinkat. Suakin is an old port on the Red Sea, lat. 19°7′ N., long. 37°20′ E., alt. 5 m. OD. Sinkat is a town within the inland plateau, lat. 18°50′ N., long. 36°50′ E, alt. 850 m. OD. Suakin receives a winter rainfall of 181 mm. per annum, and Sinkat receives a summer rainfall of 127 mm. per annum. Table 1 shows the monthly rainfall in the two stations.

* From paper presented to the UNESCO-Spain Symposium on Plant-Water Relationships (Madrid, September 1959).

TABLE 1. Mean monthly rainfall records (mm.) of Suakin (1890-1937), Sinkat (1919-1937) and Erkwit (1942-53).

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Suakin	17	7	1	1	2	0	8	7	0	25	70	43	181
Sinkat	0	0	0	2	10	10	19	58	19	7	2	0	127
Erkwit	44	14	7	8	9	5	14	52	3	11	23	28	218

The transect may be divided into three ecological belts : the littoral salt marshes, the coastal desert plain and the hills. For a botanical account of the first two belts see Kassas (1957). Here will be given an outline of the plant cover of the hills.

The hills are almost entirely composed of Basement Complex rocks including granites, granite and basic gneisses, schists and other metamorphosed sediments and volcanics.

Across these hills we may recognize six ecological zones following the coastal plain :

- I Zone of *Acacia tortilis*
- II Zone of *Euphorbia cuneata*
- III Zone of *Dracaena ombet*
- IV Zone of *Euphorbia consobrina*
- V Zone of *Euphorbia nubica*
- VI Zone of *Salvadora persica*

Table 2 gives a summary of the botanical features of the plant cover which characterises each of the six zones. We here deal with the hill slopes only and not with the water runnels nor the *Khors*. The features shown in the table are representative and not comprehensive. The area was not visited in the various seasons. Reconnaissance visits were made in December 1953, April 1954 and December 1954. The vegetational survey summarised in the table was carried out during the winter of 1955 (Dec. 1955, Jan. 1956).

TABLE 2. A summary of the analytic and synthetic records of the plant communities of Zones I-VI. (Pr. = presence %. Ab. = total estimate of abundance-sociability according to Braun-Blanquet scales, - = no record) Zone I dominated by *Acacia tortilis,* Zone II dominated by *Euphorbia cuneata,* Zone III dominated by *Dracaena ombet,* Zone IV dominated by *Euphorbia consobrina,* Zone V dominated by *E. nubica,* Zone VI dominated by *Salvadora persica.*

	I		II		III		IV		V		VI	
	Ab.	Pr.	Ab.	Pr.	Ab.	Pr.	Ab.	Pr.	Ab.	Pr.	Ab.	Pr.
Acacia tortilis	2.2	100	2.2	100	+.2	20	+.2	40	+.2	40	2.1	80
Indigofera spinosa	2.2	80	1.2	60	—	—	—	—	+.2	40	2.2	80
Seddera arabica	2.1	70	+.1	40	+.1	10	—	—	—	—	+.1	40
Commiphora quadricincta	1.2	70	+.1	20	—	—	—	—	+.2	30	+.2	30
Grewia tenax	1.2	70	1.2	70	+.2	40	+.2	40	1.2	60	1.2	80
Salsola vermiculata	1.2	70	+.2	20	—	—	—	—	+.2	30	+.2	30
Asparagus scaberulus	+.2	60	+.2	50	1.2	50	1.2	50	+.2	40	+.2	10
Lycium persicum	1.2	50	1.2	50	+.2	10	+.2	10	+.2	20	1.2	70
Acacia mellifera	+.1	50	+.1	10	—	—	—	—	—	—	+.1	10
Euphorbia thi	+.2	40	2.2	80	+.2	20	-1.2	40	1.2	40	+.2	10
Farsetia aegyptiaca	+.2	40	+.1	10	—	—	—	—	—	—	—	—
Euphorbia cuneata	+.2	10	2.2	100	+.2	20	+.2	20	1.2	40	+.2	50
Barleria acanthoides	—	—	2.1	100	1.1	40	1.1	40	—	—	—	—
Acacia glaucophylla	—	—	1.1	80	—	—	—	—	—	—	—	—
Commiphora opobalsamum	—	—	1.2	80	+.2	20	+.2	20	+.1	10	+.1	10
Cadaba glandulosa	—	—	1.2	80	+.2	30	+.2	10	—	—	—	—
Aerva javanica	—	—	1.2	80	2.2	80	1.2	70	1.2	70	2.2	80
Cassia senna	—	—	1.2	70	+.1	20	+.1	40	+.1	40	+.2	60
Tribulus terrestris	—	—	1.1	70	1.1	60	+.1	40	+.1	50	+.1	20
Cometes abyssinica	—	—	1.1	60	2.1	70	+.1	30	+.1	30	+.1	10
Andrachne aspera	—	—	+.1	60	+.1	20	—	—	—	—	—	—
Euphorbia monacantha	—	—	+.2	50	—	—	—	—	—	—	—	—
Tragus paucispina	—	—	+.2	40	+.2	50	—	—	—	—	—	—
Zygophyllum simplex	—	—	1.1	40	—	—	—	—	—	—	—	—
Aizoon canariense	—	—	1.1	40	2.1	70	—	—	—	—	—	—
Amaranthus graecizans	—	—	1.1	40	1.1	60	+.1	20	—	—	—	—
Kickxia heterophylla	—	—	+.2	40	+.2	60	1.2	60	1.2	60	+.2	20
Cadaba rotundifolia	—	—	1.2	40	+.2	10	—	—	—	—	—	—
Convolvulus hystrix	—	—	1.2	40	+.2	10	—	—	—	—	—	—
Dracaena ombet	—	—	—	—	2.1	100	+.1	10	—	—	—	—
Rumex vesicarius	—	—	—	—	2.1	80	1.1	20	—	—	—	—
Lavandula coronopifolia	—	—	—	—	2.2	80	+.2	10	—	—	—	—
Cleome paradoxa	—	—	—	—	2.1	70	+.1	10	—	—	—	—
Forskohlea tenacissima	—	—	—	—	2.2	70	1.2	40	+.2	20	—	—
Sansevieria ehrenbergii	—	—	—	—	1.2	70	+.2	20	—	—	—	—
Hyparrhenia hirta	—	—	—	—	1.2	70	+.2	20	+.2	20	+.2	10
Albuca abyssinica	—	—	—	—	1.2	60	—	—	—	—	—	—
Pupalia lappacea	—	—	—	—	1.1	60	+.1	30	+.1	30	+.1	10
Euphorbia arabica	—	—	—	—	1.1	60	1.1	50	1.1	50	+.1	20
Acacia etbaica	—	—	—	—	2.1	60	+.1	10	—	—	—	—
Capparis galeata	—	—	—	—	1.2	60	+.2	10	—	—	—	—
Hibiscus micranthus	—	—	—	—	1.2	60	+.2	40	+.2	40	—	—
Jatropha aceroides	—	—	—	—	2.1	60	2.1	70	2.1	60	2.1	80
Aerva lanata	—	—	—	—	2.1	50	+.1	10	—	—	—	—
Balanites aegyptiaca	—	—	—	—	1.1	50	+.1	10	—	—	—	—
Echinops macrochaetus	—	—	—	—	+.2	50	—	—	—	—	—	—
Tephrosia vicioides	—	—	—	—	+.2	50	+.2	30	+.2	10	+.2	10
Heliotropium longiflorum	—	—	—	—	1.1	50	+.1	10	—	—	—	—
Ruellia patula	—	—	—	—	1.1	50	+.1	30	+.1	30	+.1	10
Cenchrus pennisetiformis	—	—	—	—	1.2	40	1.2	50	+.2	40	+.2	20
Robbairea delileana	—	—	—	—	+.2	40	—	—	—	—	—	—
Commelina forskalei	—	—	—	—	+.2	40	—	—	—	—	—	—
Pancratium maximum	—	—	—	—	1.2	40	—	—	—	—	—	—
Actiniopteris radiata	—	—	—	—	+.2	30	—	—	—	—	—	—
Euphorbia abyssinica	—	—	—	—	+.2	30	—	—	—	—	—	—
E. granulata	—	—	—	—	+.1	30	+.1	20	+.1	20	—	—
Euphorbia consobrina	—	—	—	—	1.2	50	2.2	100	2.2	70	—	—
Blepharis persica	—	—	—	—	—	—	2.1	90	2.1	80	2.1	70
Cucumis prophetarum	—	—	—	—	—	—	1.2	80	+.2	50	+.1	10
Trichodesma ehrenbergii	—	—	—	—	—	—	1.1	70	1.1	70	—	—
Farsetia longistyla	—	—	—	—	—	—	2.1	70	1.1	50	+.1	10
Otostegia tomentosa	—	—	—	—	—	—	2.1	70	2.1	70	—	—
Solanum albicaule	—	—	—	—	—	—	1.1	70	+.1	50	+.1	20
Matthiola elliptica	—	—	—	—	—	—	1.1	60	+.1	60	+.1	10
Podostelma schimperi	—	—	—	—	—	—	1.2	60	1.2	60	1.2	70
Danthoniopsis barbata	—	—	—	—	—	—	1.2	50	+.2	10	—	—
Caralluma retrospiciens	—	—	—	—	—	—	1.2	50	1.2	40	—	—
Abutilon pannosum	—	—	—	—	—	—	1.2	40	+.2	30	+.1	10
Vernonia cinerascens	—	—	—	—	—	—	1.1	40	—	—	—	—
Leptadenia lancifolia	—	—	—	—	—	—	+.2	40	+.2	40	—	—
Coleus igniarius	—	—	—	—	—	—	+.1	40	+.1	30	+.1	—
Euphorbia nubica	—	—	—	—	—	—	1.2	70	2.2	100	+.2	50
Panicum turgidum	—	—	—	—	—	—	—	—	1.2	50	+.2	40
Chrysopogon aucheri var. quinqueplumis	—	—	—	—	—	—	—	—	1.2	50	+.2	40
Polygala liniflora	—	—	—	—	—	—	—	—	1.1	40	+.1	10
Aloe eru	—	—	—	—	—	—	—	—	+.2	40	1.2	60
Sarcostemma viminale	—	—	—	—	—	—	—	—	+.2	40	—	—
Pulicaria crispa	—	—	—	—	—	—	—	—	+.1	30	—	—
Salvadora persica	+.2	10	+.2	10	—	—	—	—	+.2	20	2.2	100
Seddera latifolia	—	—	—	—	—	—	—	—	—	—	1.1	80
Heliotropium strigosum	—	—	—	—	—	—	—	—	—	—	1.1	70
Chrozophora oblongifolia	—	—	—	—	—	—	—	—	—	—	1.1	60

Zone III is undoubtedly the less arid. *Dracaena ombet* is the most salient feature of the plant cover, see phot. 1 and 2. The growth of such trees as *Dracaena* and *Balanites aegyptiaca,* and such plants as *Pancratium maximum, Albuca abyssinica, Cleome paradoxa, Sansevieria ehrenhergii, Commelina forskalei,* and—indeed—the fern *Actiniopteris radiata,* bears witness of a greater water income. Again the trunks of *Dracaena* are often mosaiced by lichen growth. The total plant coverage ranges from 20 to 30 %.

Zones IV, V and VI on the inland side and zones II and I on the seaward side show gradual increase in aridity. Zone I, with *Acacia tortilis* as the most abundant bush, is the natural continuation of the desert plain which extends from the foot of the hills to the sea coast, see phot. 3. The associated species are typical members of the desert plain communities : *Indigofera spinosa, Commiphora quadricincta, Salsola vermiculata, Grewia tenax,* etc. The aridity of the habitat is denoted by the limited number of species recorded in the stands of this zone (12 spp.), and the sparse plant coverage which does not exceed 10 %.

Zone II, with *Euphorbia cuneata* (see phot. 4) as the most abundant bush, represents a betterment of the water resources as compared to zone I : a greater variety of species (30 spp.) and a less sparse plant coverage (5-20 %). *Acacia glaucophylla, Commiphora opobalsamum, Cadaba glandulosa, Barleria acanthoides, Aerva javanica,* are common associates.

Zones IV (see phot. 5) and V are closely related and they represent transition from the *Dracaena ombet* zone to the inland plateau and its hills. *Euphorbia consobrina* dominates a zone which is less arid than the *E. nubica* zone.

Zone VI which is the inland terminus of the described transect lies within the summer rainfall country and apparently enjoying very little of the maritime effect. The hills bear a depauperate plant cover with *Salvadora persica* as the most abundant plant. In fact the whole district, hills and *Khors* alike, is covered with various communities dominated by *Salvadora*. In the Khors (see phot. 6) the plant coverage ranges from 25 to 60 %, on the hills it rarely exceeds 5 %. There are close

structural and compositional similarities between the plant cover of the hills of zone VI and those of zone I.

The suggested explanation for this zonation is this. As the continental northerlies pass over the warm water of the Red Sea, they absorb a considerable amount of moisture. Where they reach the coast, they cause convectional rain which decreases inland. As they cross the coastal plain, the moisture-laden air encounter the hills causing orographic rain and other forms of condensation. The seaward (east) slopes receive a greater share of this rain. The higher hills further inland receive, by virtue of their altitude, more of this moisture than the lower hills and buttes. This will have a marked effect on the water resources which will vary according to the altitude and the site of the hill (distance from coast and situation with regards other hills).

After passing over a certain stretch of these hills, the northerlies resume their dry continental nature and will bring little benefit to the inland hills.

The hills of zone I lie within 10-15 km. from the coast and rise to 150-250 m. OD. Zone II follows and extends to 25 km. from the coast, and rises up to 450 m. OD. The *Dracaena* zone is further inland (25-40 km. from the coast) and its jagged mountains rise up to 900 m. OD. The *Dracaena* zone lies above the level of the low winter clouds and is often swathed in these clouds. The hills of zones IV and V lie at 35-55 km. from the sea and are usually lower than the upper limit of the *Dracaena* zone. High mountains may have a top zone of *Dracaena* followed by a slope zone of *Euphorbia*.

ERKWIT MIST OASIS

The second example is a natural continuation of the first. Erkwit, the summer resort of Sudan, lies at about 45 km. (*c.* 28 miles) to the south-west of Suakin and about 30 km. (*c.* 20 miles) to the east of Sinkat, see phot. 7. The Erkwit plateau lies at the edge of a steep escarpment dropping abruptly (600 m.) to the Red Sea plain. The moisture-laden winds meet no dissipating obstacle before impinging on the cool *jebels* (mountains) of Erkwit which rise to 1100-1500 m. OD.

Within the limited area of Erkwit (30 sq.Km.)., the nearer to the north-eastern boundary the wetter will be the habitat. The south and south-western boundaries merge into the inland arid plateau. Again the higher the level, the more moist it will be. In consequence there is a marked zonation in the plant life parallel to the north-eastern boundary-line, with local differences due to elevation. Five vegetational zones may be recognised :

I Zone of *Maytenus senegalensis*
II Zone of *Maytenus senegalensis-Euphorbia abyssinica*
III Zone of *Euphorbia abyssinica*
IV Zone of *Dracaena ombet-E. abyssinica*
V Zone of *Euphorbia thi.*

For detailed accounts of the vegetation see Kassas (1956a) and Troll (1935). We shall here give a summarized outline of the plant cover of these zones. Table 3 presents an abstract of the data about a few of the more characteristic species recorded in the area.

Zone I is characterized by evergreen trees and shrubs and drought intolerant plants such as *Maytenus senegalensis, Euclea schimperi, Dodonaea viscosa, Diospyros mespiliformis, Coleus barbatus, Nepeta biloba,* etc. Ferns such as *Actiniopteris radiata, Cheilanthes farinosa, Onychium melanolepis* are commonly found together with various mosses and liverworts. All the trees and shrubs are densely bearded with lichen growth. The total plant cover ranges from 50 to 70 %.

Zone V represents the inland limit of the maritime effect. Lying at the margin of the Erkwit oasis, this zone merges into the Sinkat plateau. The total plant cover ranges from 5 to 10 %, and include hardy bushes and herbs : *Euphorbia thi, E. cuneata, Barleria acanthoides, Salsola vermiculata, Lycium persicum,* etc.

Zone II, III and IV represent gradual transition from the wet zone I to the north-east and the less favoured zone V to the south-west. There are also noticeable differences between the vegetation of north and east slopes of *jebels* as compared to south and west slopes. This is especially noticed on *jebels* that lie at the boundaries between zones, and suggests

TABLE 3

Summary of data showing presence estimates (%) of a few of the more characteristic species recorded in Erkwit. For details see Kassas (1956 a).

	ZONES				
	I	II	III	IV	V
Trees and shrubs					
Maytenus senegalensis	100	100	60	10	—
Euclea schimperi	100	100	60	—	—
Dodonaea viscosa	90	60	20	—	—
Diospyros mespiliformis	90	30	30	—	—
Rhus abyssinica	80	10	10	—	—
R. flexicaulis	80	40	30	—	—
Carissa edulis	70	40	30	—	—
Phoenix sp.	70	10	—	—	—
Ximenia americana	60	20	10	—	—
Acacia etbaica	70	100	100	80	100
A. tortilis	—	50	80	50	25
Euphorbia abyssinica	20	100	100	100	50
Dracaena ombet	—	—	10	100	—
Lycium persicum	—	—	—	60	75
Undershrubs and herbs					
Coleus barbatus	100	70	50	—	—
Nepeta biloba	100	40	—	—	—
Lavandula coronopifolia	60	100	60	40	—
Kalanchoe glaucescens	100	100	60	40	25
Indigofera spinosa	20	70	100	100	75
Aloe eru	—	10	60	80	25
Caralluma pencillata	—	—	40	60	50
Euphorbia thi	—	—	—	100	100
Blepharis edulis	—	—	—	100	60
Fagonia myriacantha	—	—	—	70	75
Salsola vermiculata	—	—	—	80	75
Euphorbia cuneata	—	—	—	50	100
Seddera virgata	—	—	—	70	75
Barleria acanthoides	—	—	—	20	75

that the seaward slopes receive greater amounts of moisture than leeward slopes.

Within the range of *jebels* in zones I and II, the vegetation indicates wetter conditions at higher compared to lower levels. Had the rainfall been the only water resource, one would have expected the lower levels to be less dry as they receive run-off water. The actual pattern shows that the vegetation exploits the atmospheric moisture in forms apart from rain.

It is suggested that the conditions that make the limited area of Erkwit an oasis amidst arid country are : firstly, it combines the summer rainfall of the territory to its west and the winter rainfall of the Red Sea coast to its east; secondly, it receives sea-mists and wind-borne moisture which face no obstacle till they meet the edge of the Erkwit plateau. Within the area of Erkwit, local differences in water resources—due to physiographic factors and distance from the edge of the escarpment—cause the zonal pattern of the vegetation.

The studies, reported in the previous pages, were carried out during the period 1953-1956. The writer has recently been informed by botanists, who visited the Erkwit area in 1959-1960, that the *Dracaena ombet* is dying and that dead stumps are commonly seen in the *Dracaena*-zone but living trees are rare. Regeneration is either extremely scarce or non-existing. Grazing may have caused the suppression of regeneration and old trees may have reached their age limit. Other less noticeable species may also be gradually disappearing. Erkwit was previously protected as a natural reserve. The full explanation of such remarkable elimination of *Dracaena* is, however, difficult without careful investigation, see phot. 8.

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Photo 1. Looking down from a hill slope in the *Dracaena ombet* zone. Trees of *Dracaena* are seen in the foreground. *Acacia tortilis* scrub is seen in the valley (*Khor*) below.

Photo 2. A hill slope in the *Dracaena* zone. Note the dead stump near the top of the hill. *Euphorbia consobrina* scattered inbetween the trees.

PHOTO 3. Zone of *Acacia tortilis*. The valley in the foreground with a thick growth and the hill slope with an open scattered growth.

PHOTO 4. Zone of *Euphorbia cuneata*, the hill slope is covered with an open scrub dominated by *E. cuneata*.

PHOTO 5. Zone IV, the hill slope is covered with an open community of *Euphorbia consobrina*.

PHOTO 6. Inland plateau and hills, zone VI. *Salvadora persica* dominates the Khor and the hill slopes.

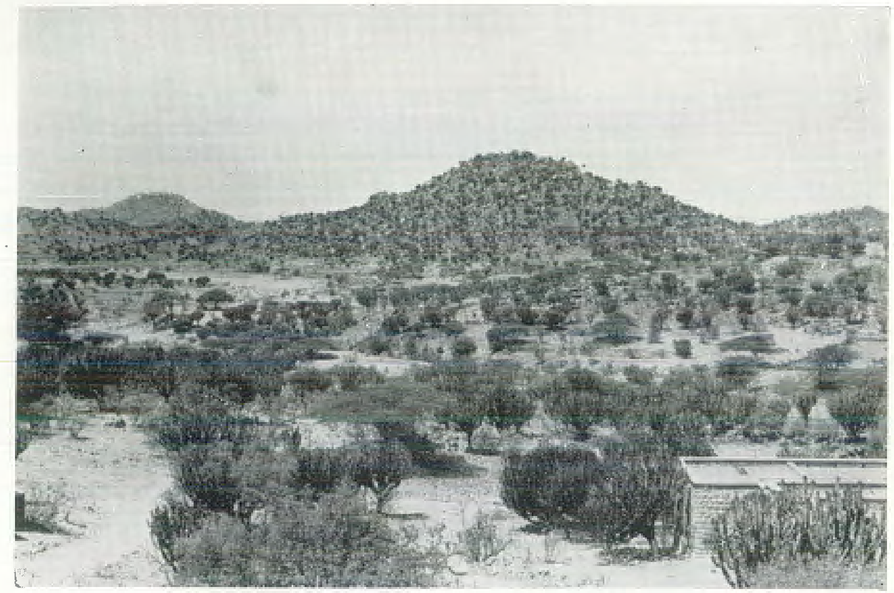

PHOTO 7. General view of Erkwit showing the zone of *Euphorbia abyssinica*.

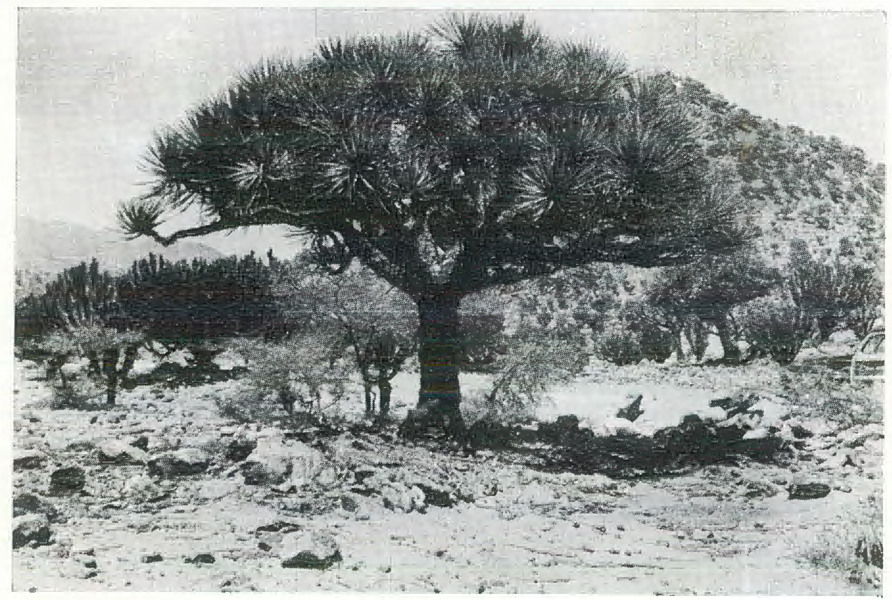

PHOTO 8. Zone IV in Erkwit. *Dracaena ombet* is seen in the foreground and is very abundant on the hill slopes.

STRUCTURAL STUDIES
IN NORTHERN IRAQ AND THEIR BEARING ON ZAGROS TECTONICS

BY

RAOUL C. MITCHELL-THOMÉ

INTRODUCTION

The Zagros Range, lying chiefly in Iran but extending across the frontiers of Turkey and Iraq, with a length of some 1700 km and with peaks rising over 4300 m, represents one of the truly grand and magnificent mountains chains of the world. Like some other great ranges, such as the Himalayas, Andes, etc., the relative inaccessibility of the Zagros has hindered the prosecution of systematic, detailed geological investigations.

Scattered geological accounts of the Zagros date back many years, but the first important synthesis of the structure appeared thirty years ago when de Boekh, Lees and Richardson (1929) presented a stratigraphic and tectonic compilation, and today this publication has achieved classic proportions. Excellent though the study is, one notes however, as is so frequent in geology, that old ideas, old theories tend to linger on, acquire a certain prestige, and seem rather resentful of the incursion of newer investigations, more recent concepts and theories. Studies carried out during the last few years in the Zagros tend to cast doubt on some of these hoary and honoured contentions.

The region lying between the Rowanduz and Lesser Zab Rivers in Iraq was chosen as an area of study. Shorter reconnaissance surveys further N and in the Sulaimaniya region to the S, as well as rapid reviews of some territories in Iran, led to the belief that this section was perhaps more representative of the Range as a whole, certainly within Iraq. One

is well aware of the partial and incomplete nature of this study, of the danger of arguing from the particular to the general. In spite of such, it is believed that the results and opinions based upon these investigations may be of some import to the interested reader. A precise and detailed knowledge of the tectonics of this Range must wait many years, and the sum total of our factual data at this time is indeed most fragmentary.

The « Classic» concept of Zagros tectonics.

De Boekh, Lees and Richardson (*op. cit.*), as well as others before and after them, e. g. Pilgrim (1908, 1924), Stahl (1911), Gregory (1918), Argand (1924), Arni (1939), Picard (1939), Heron (1943), Schroeder (1944), O'Brien (1948), Gray (1949), Henson (1951), also Lees (1938, 1952, 1953), described the Zagros Range as comprising a series of nappes, piled one on top of the other, and all pushed towards the SW. The Range represents the orogenic relief resulting from, deformation within the Tethyan geosyncline, which latter was squeezed between the Arabian Foreland and the Zwischengebirge of Central Iran. The roles of subsidence, taphrogenesis and tangential compression are given varying importance, both spatially and temporally, by various writers, with geosynclinal migration an accompaniment to orogenic disturbances. The beginnings of orogenesis date from the early Mesozoic, but the most intensive deformation occurred in the late Neogene. Successive waves of diastrophism hurled themselves against the rigid Foreland lying to the W, SW and S, the orthogeosyncline suffering greatest deformation, less intense in the outer miogeosyncline, and only feeble reverberations being experienced at the edge of the Foreland in the Buckled Labile Shelf zone. (Mitchell Press) Diagonally across the Range, generally from SW to NE, the degree of intensity of disturbance increases till in the Nappe Zone enormous overthrust masses have moved upwards and outwards, raising from the depths basement material, sometimes by means of diapirism, which spilled over into the miogeosyncline and, on occasion, scattered the tectonic débris as far as the edge of the Foreland.

Implicit in the writings of previous workers are the following : (1) nappes have an origin deep within the geosyncline, (2) thrustplanes and soles continue to great depth, (3) from SW to NE across the Range there

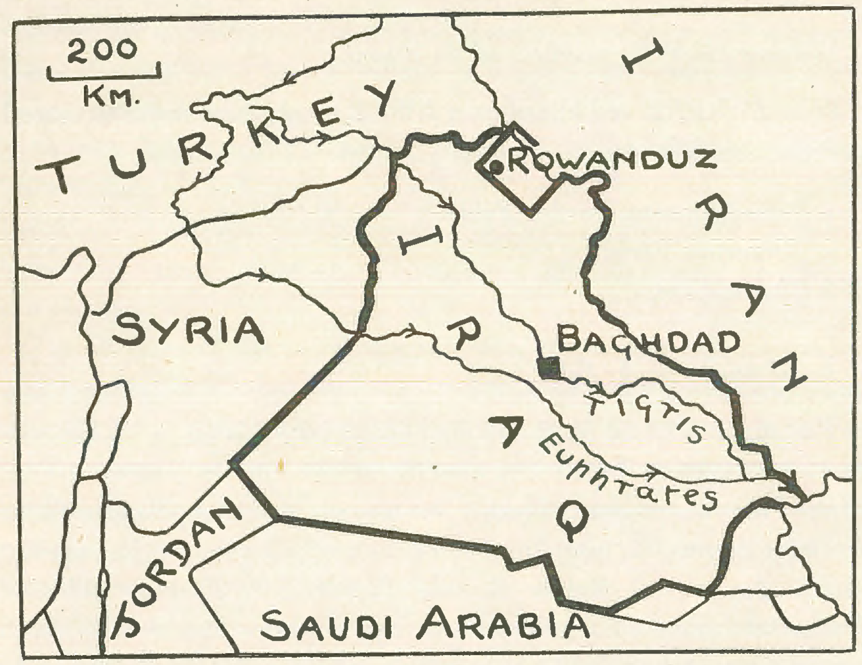

Fig. 1.

occur a series of « steps», each « step» more intensely folded, higher in topographic elevation and of older folding age than the previous one to the SW, (4) mineralization increases towards the NE because of greater metamorphism in this direction, bringing up from the depths of intrusives more profound channel-ways represented by plunging thrust-planes, (5) all structures are asymmetric, with folds and thrust movements directed from the interior towards the Foreland.

Whilst almost universally the basic idea has been that of one-sided thrusting and tangential compression towards the Shield area, it is only right that we should mention that Henson is dubious about this. In a letter dated Nov. 25th 1958, he comments as follows : « I consider that the tectonic framework of the Middle East is determined by extensions of the Afro-Arabian rhegmatic fracture system ; and that the integrated effects of new and reactivated transcurrent shearing movements which have occurred in the basement, supplemented by those of differential block subsidence may account for some or all of the crustal shortening which has occurred selectively along old lines of weakness (geosutures)».

Major structural characteristics of the Region.

From SW to NE, and alined on a NW-SE trend, three major structural units can be defined :

1. Autochthonous Border Folds.
2. Transition Zone.
3. Thrust Zone.

Autochthonous Border Folds.

The strata involved in the folding range from Liassic to Palaeocene or Lower Eocene. In the area here discussed, only the innermost edge of the Folds are present. Further out towards the Mesopotamian Plains the folds decrease in magnitude and intensity and younger incompetent strata—Upper and Middle Miocene Fars Series, Pliocene Bakhtiari Formation—show a different tectonic style (ejektive Typ of Stille) with overturning of folds and reverse faulting directed towards the SW. The Border Folds of our area, on the other hand, are not only higher topographically, more intensely deformed, but comprise largely massive competent limestones, mostly of Cretaceous age, in which the large anticlinal structures have exposed cores of Jurassic and Lower Cretaceous, and which display a dejektive Typ of fold groups.

Some of the anticlinal folds are indeed large—perhaps they might even be described as micro-anticlinoria, as subsidiary anticlinal folds along the flanks are common—extending for 25 km long, 10 km in width and with amplitudes of 2500 m. The fold patterns are most complex, virgations and syntaxis, faulting—reverse, thrust, transverse, gravity gravity collapse, larger structures squeezing and interfering with the development of smaller structures—all such features render a chaotic fold ensemble.

In the Salan-Dergala region, the major anticline, which in places is overturned and thrust towards the NE, interfered with the development of the anticline between Basaria and Dergala, pushing and thrusting deeply against it, with the result that this smaller anticline developed a thrust along its SW limb, so that Liassic limestones and dolomites

come to rest against softer, more pliable sediments of Upper Cretaceous-Lower Eocene age. In the process, a wrench fault was formed, offsetting the thrust.

Between Razan and Chimera, a SE-plunging anticline has suffered intense shearing and faulting along its SW limb, a step-series of gravity faults and strike-slip fault pinching another anticline which coalesces here into a mass of contorted, splintered and imbricated strata of unusual complexity.

The NE flank of the anticline just SW of Razan has been so pushed over towards the NE that this flank was left in an unsupported condition, with the result that it collapsed and splayed forth an apron of limestone rubbly breccia. This condition, viz. the NE limbs of anticlines being pushed over so far that they become unstable and give rise to gravity-collapse structures, is common within the Border Folds, and no less common in the Thrust Zone.

The nearer to the Transition Zone, the more intense the deformation, with thrust and reverse faulting, inclined and recumbent folds and isoclinal folds all showing a movement towards the NE. (Note that only the younger, less competent beds nearer the Mesopotamian Plains are asymmetric towards the SW.)

Further away from the Transition Zone, e. g. between Rowanduz and Gulan, gravity and normal faulting is commoner, excessive strain being more readily accomplished in this manner. Tear faults, whether of wrench or strike-slip type, are more associated with localities where the deformation was more intense, being particularly liable to occur along weakened overturned or recumbent anticlines.

The alluvial Qalah Dizeh plain is a structural depression. The N and S margins of the plain show folds plunging towards it. The presence of scarplets, mostly apparently fault-line scarplets of resequent type, suggest that fault movement is taking place at present, the movement possibly aided by the large annual increment of load within the plain. In the Rania region there is a suggestion of horst structure whereby massive, competent Qamchuqa Limestone has been raised above the Rania and Qalah Dizeh structural alluvial plains, the antecedent Lesser Zab River cutting through the structure at the Darband gorge.

Transition Zone.

Both stratigraphically and structurally, this zone is intermediate between the other two. Rocks ranging in age from Cenomanian to Middle Miocene show several unconformities, lensing-out of the beds is common, squeezing and pinching of the rocks is characteristic. Structurally, both folding and thrusting are equally prominent, but squeezing and imbrication effects are more significant than in the Border Folds.

The breadth of the Zone varies considerably. Between Chimera and Barade the Thrust Zone lies close to the Border Folds, the intervening argillaceous rocks of the Bastasten Series having undergone extreme pinching and folds have almost vertical limbs. On the other hand the narrow Transition Zone in the Ganav region comprises stronger, more resistant strata, displaying extensive jointing and close-packed shear-thrusts resulting in imbricate structure. In both, localities —Chimera-Naopurdan and Razga—where this Zone broadens, more competent strata are exposed and fracturing is more common than folding. In these localities also there is evidence within the Thrust Zone (q. v.) that some at least of the basal shear planes curve upwards. The possible significance of this will be mentioned below.

Within the Transition Zone, two important thrusts are present. E of Chimera, the Chimera Series have been thrust-folded over and on to the Tangero shales, marls, etc., such that the SE-plunging anticline between Razan and Chimera has been compressed, its nose pushed in and upturned, and actually forms an inverse plis en retour, i. e. pointing upwards instead of downwards. In turn, the frontal thrust of the Thrust Zone has caused the Chimera Series to form recumbent isoclinal folds, and small klippen suggest horizontal translations of at least 1.5 km. In the Razga area, the Shahidan argillaceous rocks are widely exposed and have been intensely puckered, indicating a high degree of plasticity and displaying a complex structural style more commonly associated with diapirism. At the junction of the Shahidan Shale and Bastasten Series, a thrust has allowed the plastic Shahidan to over-ride the latter.

Throughout the Transition Zone, the physical character of the rocks has had a profound influence on the type of structures which developed, competent and incompetent, plastic and rigid, strong and weak, hard and friable, all such properties determining intimately the manner and type of deformation undergone. As a generalization, one can say that tougher, harder rocks tend to fracture, more pliable, softer rocks tend to fold. Frequently it is noted that unconformable junctions serve as loci of thrust planes, and very often the thrust plane itself has become folded in the process. Some of the largest and most impressive examples of drag folding which the writer has seen can be found within the Zone, where 20 m thick shales, lying between competent limestones, show as many as a hundred individual laminae all closely folded in the manner of similar folds. In truth, the Zone constitutes an excellent laboratory of Nature for the study of structures.

Thrust Zone.

Occupying the highest regions and extending far into Iran lies a zone in which translation of rock masses along thrusts of various types is characteristic, the rocks being thus allochthonous. Four distinct units can be recognized, based chiefly on the rock types involved, and usually but not always separated by structural boundaries.

Unit I, the lowest, comprises essentially argillaceous rocks belonging to the Kewarta Group. The greatest development is in the Naopurdan area, but also in the Razga region the Shahidan Shales lie partly within the Thrust Zone. These plastic beds perform the function of a sole, separating the autochthon from the allochthon. As would be expected the strata here show a very high degree of contortion. Shear zones, with shear folds, sheet structures, imbricate structures, décollements, bedding thrusts, folded thrusts, highly inclined and recumbent, tight, isoclinal folds are all excellently displayed. In tracing the Kewarta and Shahidan beds from NW to SE it is noticed that the proportion of pelitic rocks increases, whereas psammitic and psephitic, as also limestones and dolomites, become less important. It is thus believed that the absence of Unit I in the SE is due to the fact that the higher Unit II has completely over-ridden its plastic, lubricating base, whereas to the NW the increasing proportion of non-pelitic rocks have created more friction and thus

hindered the forward movement of the higher thrust unit. Some substantiation of this is seen in the greater development of dynamically metamorphosed metasediments in the Naopurdan area.

Unit II is composed principally of extrusives, mostly of basic type although acidic volcanics as well as sediments—shales, mudstones, limestones, chert beds—are to be found. From NW to SE these rocks, comprising the Wasan, Popadar and Beshir Extrusives, constitute a thick series, with everywhere a thrust-contact, usually disturbed, with either Unit I or then the Transition Zone. Very common throughout this unit are high-angle reverse faults, all hading towards the interior, resulting in imbricate structures. Such features usually testify to a « basement» low-angle thrust plane, and indeed such is the case here. In the Pushtashan and Zharawa valleys the basal thrust plane of Unit II is not only of low-angle type but is also curved, the degree of upward curvature becoming greater as one progresses down these valleys.

Many of the rocks of Unit II, especially the rudites, are not firmly cemented, and where such rocks have been brought to the high escarpment rims overlooking the Transition Zone, vast aprons of rudaceous material descend down the precipitous slopes, forming gravity-collapse scree deposits.

Innumerable dykes and sills, also small bosses of granodiorite, quartz-monzonite, diorite and norite, are generally intensely shattered, with dynamothermal metamorphic aureoles and zones formed, especially where in contact with calcareous host rocks. Volcanic cones, mostly involving basic lava extrusions, appear to be concentrated in the area W of Hero.

Unit III. This is a relatively narrow zone overlying the extrusives and is not everywhere present. Lithologically it comprises rocks characterized by smooth, slippery, splintery qualities, such as phyllites, slaty shales, chlorite-schists, talc-schists, tremolite-schists, etc. The excellent lubricating properties of these rocks means that again as in Unit I we have developed a sole for the thrusting of the higher unit. As distinct from the predominantly argillaceous rocks of the first Unit, those of Unit III show a far greater foliate structure, fracture and shear cleavage, lineation, polishing, grooving, slickensides. The last-mentioned often show high « steps» which cause pockets of the higher unit in which extremely contorted strata have been frictionally metamorphosed.

Considering the excellent lubricating qualities of the rocks involved in this unit, one might have supposed that the higher unit would, completely over-ride the lower and come to rest in juxtaposition with Unit II, Unit I or perhaps even the Transition Zone. Again it seems apparent that upward-curving thrust planes at the base of Unit IV are responsible in retarding forward movement.

Unit IV includes all the higher mountainous area and extending into Iran. Various metamorphics are predominant but ultrabasic and basic extrusives and intrusives, acidic and basic dykes as well as sediments also occur. In general the metamorphics represent altered calcareous rocks—marbles, calc-schists, garnetites, ophicalcites, amphibolites, etc.—or then tough resistant rocks such as gneiss, hornfels, quartzite, etc.

Folding is singularly lacking in this unit and instead shear jointing, wrench and strike-slip faulting, reverse and thrust faulting are especially characteristic.

The Metamorphic Series illustrate various kinds of metamorphism, dynamic and dynamothermal being most prevalent, but the intrusive masses show superb contact metamorphic aureoles.

Nowhere else in the Rowanduz-Lesser Zab area is the scenery more magnificent, the topography more varied, the relief greater. Towering scarps, some rising almost 2000 m at 50° or 60° angles present well-nigh impenetrable barriers to passage through the Zagros Range, except where the rivers have carved stupendous gorges.

Mention has been made more than once of basal thrust planes between the units of the Thrust Zone which are curved, concave upwards. In the headwaters region in Iran of the Pushtashan River, on the eastern slopes of Qandil Mountain, 3448 m, thrust planes within the Metamorphic Series have their southern and southwesterly extremities curved upwards into angles approaching 20°, i. e. here the thrust planes are hading to the N and NE but at very much steeper angles than further back up the valley. In the same valley but further S, the basal thrust plane of Unit IV dips gently to the SSW, but E of Pushtashan this same thrust plane can be seen changing from a gentle southward dip to first

a small then a steeper dip to the *N*. It seems to be a frequent occurrence that thrust planes within the Thrust Zone curve upwards at their exterior margins, that further in the interior these same planes may be dipping gently in either a general SW or then NE direction. This feature calls to mind tectonique d'écoulement, with the superficial displacement of masses under gravitational action.

In spite of all that has been written on this hypothesis of orogenic movements, it still appears to be in most difficult—indeed often, impossible—task to distinguish between masses which have glided forward and masses which have been pushed forward. Inherent in the concept of tectonique d'écoulement is the postulate of having some obstacle which brings the gliding mass to rest, the moving masses have been translated gravitationally downwards and the planes separating differentially moving masses—the thrust planes—curve upwards as the masses attempt to overcome the obstacle. In out area of discussion, the massive, competent beds of the Border Folds, folded and thrust, as already mentioned, towards the NE, are believed to have acted as obstacles to the southwestward directed thrust masses. The competent folded beds formed the barrier against which the thrust masses had to move upwards and over. In order to attempt this feat, the thrust planes curved upwards, but the steepening incline nullified the momentum gained by the masses in their downward gravitational gliding.

The more cautious advocates of tectonique d'écoulement, such as Gignoux, Moret, Gagnebin, have never claimed that whole vast mountain chains such as the Alps, for example, have been formed solely due to such causes. Gagnebin (1945) speaks for the group when he states : « La tectonique d'écoulement n'est, en fait, qu'un complément à la tectonique classique».

Here in the Zagros, we make no claim that this mighty chain is to be explained on geological grounds uniquely by gravity slide tectonics. But on the other hand, in the region of interest here, it seems highly probable that such a hypothesis is workable in explaining the structural features noted.

Tectonic Development of the Region.

Pre-Jurassic beds being absent, we shall begin with Jurassic times, although it is presumed that similar conditions prevailed during the Triassic.

Widespread marine deposition occupied the present site of the Zagros and far into Iran, with, however, shallow lagoonal areas in which the Sarki evaporites were formed. The Sarki and Sekhanian calcareous sediments were succeeded by Kimmeridgian-Aalenian deposits showing a carbonaceous content, possibly indicating relatively stationary, deep-sea conditions. There followed more normal marine sedimentation, with the development of a thick series of thin and also massive limestones, dolomites, with minor shale and mudstone occurrences. These marine deposits are thickest in the Rowanduz-Gulan area, suggesting deeper sea here which later influenced the locus of incipient folding within the Border Folds. The physical character of these pre-Campanian rocks was such that folds of large dimension later developed, the more regular and larger folds, however, interfering with the growth of smaller ones. The geosynclinal phase of sedimentation was interrupted in Coniacian-Santonian times by earth movements causing preliminary foldings and some thrusting, leading to the initiation of a mountain chain. The succeeding Shiranish and Tangero Formations are thus syn-orogenic facies deposits, with some admixtures of post-orogenic facies. Variations in thickness of these Formations point to the influence of foldings and concomitant erosive processes.

The denudation of these earlier folds gave rise, in Maestrichtian-Palaeocene times to typical molasse deposits which formed in a basin to the NE of the embryo chain—the Transition Zone. The chain now formed an imperfect barrier with a basin to the NE and to the SW. These early earth movements were all directed towards the NE. During the Early Tertiary the geosynclinal trough NE of the range continued to subside, and post-orogenic sedimentation continued, during which time the Shahidan Shale, Kolosh Formation, Kewarta Group and Endezah Limestone were formed. Important also during this period was the vulcanicity, represented by the Wasan, Popadar and Beshir Extrusives.

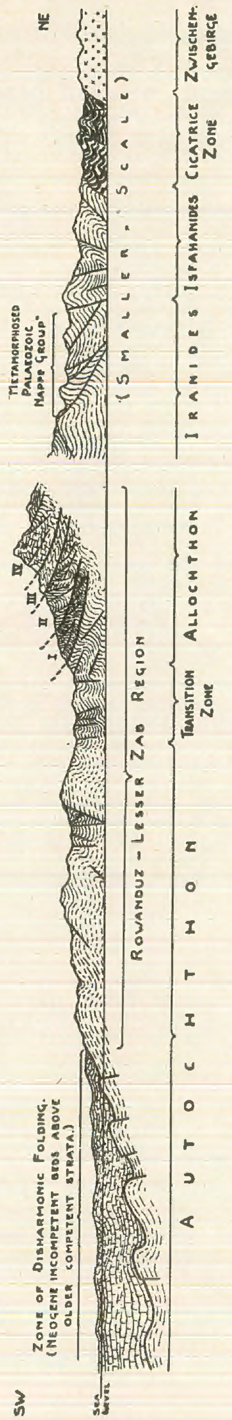

Fig. 2. Schematic Tectonic Profile Across the Zagros Range.

This NE geosyncline is thus a eugeosyncline, whereas the trough lying SW of the early mountain barrier constituted a miogeosyncline, as vulcanism was absent here, it occupies an external position and experienced far less intense disturbance.

Marine deposition continued within the NE eugeosyncline into the Oligocene and possibly even the Miocene, with clastic sedimentation progressing as a result not only of the erosion of the chain but also consequent upon disturbances within the trough.

In the Middle Tertiary, beginning at the end of the Eocene, the eugeosyncline underwent compression and succumbed to more powerful deformation than had hitherto taken place. Orogenic uplift of the Border Folds area occurred, along with downwarping of the basin to the NE. The latter was eventually compressed and raised into a second mountain range. Dynamic metamorphism affected the sediments which became the thrust-front. The extrusives next felt the compressive efforts, over-riding the lower sediments. The two lowest units of the Thrust Zone have been relatively unaffected by metamorphism. whereas the two higher units show much greater alteration. From this we might surmise that the NE margin of this compressed eugeosyncline underwent the earliest and most intense compression, the central and SW margin of the trough, represented by the two lower Thrust Zone units and also partially the Transition Zone, being much less drastically deformed. The last to feel the pressures imposed were the rocks of Unit I and some within the Transition Zone—Shahidan Shales, Kolosh Formation, Kewarta Group. The incompetent nature of the constituent rocks allowed of folding, puckering and squeezing rather than fracturing. The more superficial character of the foldings here probably began about the end of the Lower Miocene.

There was thus a minor period of thrust development which extended from about the end of Eocene to about the end of Lower Miocene. (An earlier very minor thrust period is associated with Coniacian-Santonian times.) During these events the Transition Zone, which initially represented the piedmont region of outwash-fans of the early mountain chain, acquired the features of an intra-montane basin, which, during Oligocene and Lower Miocene, acted as a marine inlet. Various rudaceous horizons

present in this Zone, e. g. Maestrichtian, Lower Eocene, Lower Miocene, represent thick outwashfans into this intra-montane marine basin.

By the beginning of the Late Tertiary, the previously formed mountain chain erected in the Late Cretaceous, had been largely denuded down to sea level and beginning in the Middle Miocene, marine sedimentation of the Fars Formation began.

In the Upper Miocene-Pliocene, once again intense disturbances were experienced. The Border Folds area was orogenically rejuvenated and major thrust movements, characteristic of the Thrust Zone, were set in motion. Unit I was overthrust by the Extrusives of Unit II, with the pliable rocks of the former acting as a sole : Unit IV over-rode Unit III, the latter performing the same function. Unit IV was evidently thrust well in front of Unit II, where W of Halsho an excellent fenster is displayed with the lower Unit entirely surrounded by the higher. What might have been the maximum magnitude of lateral movements of these thrust masses is not clear, but movements of the order of 8 to 10 km can be established in some of the deep valleys cutting through the high ranges.

During this period of intense disturbance, Miocene sediments of Transition and Border Folds Zones were folded in the same direction as the thrust movements, i. e. towards the SW. The earlier folded mountain range, now resurrected, felt the impact of these strong SW-directed compressions, but the massive, tough, competent strata comprising the folds, which had been pushed to the NE in the former orogeny, had acquired a firm « set», and firmly resisted all efforts to overturn them towards the SW. On the other hand, the softer, less competent Miocene and Pliocene beds which were laid down on the more external borders of the Border Folds Zone did come under the influences of this Late Tertiary diastrophism, and are accordingly folded and reverse-faulted towards the SW. By the same token, Miocene strata within the Transition Zone and Unit I also were subjected to SW-directed movements.

The renewed uplifting of the Border Folds, and the piling upwards of great thrust masses created an impressive new orogenic relief. This new range—the Zagros Mountains as we see them today—became

subject to powerful denudation and provided the source sediments for the very coarse clastics which comprise the Pliocene Bakhtiari Formation, deposited at the external edge of the Autochthonous Border Folds and fronting the present alluvial plains of Iraq and Iran.

As both the Fars Series (Middle and Upper Miocene) as well as the Bakhtiari Formation have been folded towards the SW, this last orogeny dates from the Pliocene—the Wallachian orogenic disturbance.

That this ultimate disturbance has not finally ceased is illustrated by the frequency and disastrous character of seismism which typifies the Zagros Range—a still-lingering relic of an instability which began in the eugeosyncline in Late Cretaceous times, some 60-70 odd million years ago. The scars and wounds of the earth take a long time of heal.

CONCLUSIONS

Within the area here described, the following is to be noted :

(I) There is no indication of thrust planes plunging in depth.

(II) Within the Thrust Zone, the major thrusts are very gently, inclined either to the NE or SW, and commonly the extremities are curved upwards.

(III) Zones of greater disturbance are not extensively mineralized, and, in fact, the entire region shows poor mineral economic prospects.

(IV) No « basement» material is exposed.

(V) Nappes are not present.

As the last-mentioned item may cause considerable surprise, it is necessary that we define the term (Mitchell, 1958). A nappe is a recumbent fold, the inverse limb of which has been attenuated and stretched to the point of shearing, the upper detached block being displaced in a predominantly lateral direction along a fracture surface which usually conforms to the thrust or low-angle type. When we have a pile of nappes, the lowermost, hence the oldest nappe, is separated by a sole from the substratum. Conceiving of nappes in the sense given, they are lacking in the area of study.

The geographical Zagros Mountains include several tectonic units. The orthogeosyncline, bordered on the W and SW by the Arabian Foreland, on the N and NE by the Central Iranian Zwischengebirge, includes the following units from SW to NE : Autochthonous Border Folds, Iranides, Isfahanides, Cicatrice Zone (Mitchell, Press). Only along the NE margin of the Iranides are deeper basement Palaeozoics brought to the surface, and only within the Isfahanides—the « Metamorphosed Palaeozoic Nappe Group» of de Boekh, Lees and Richardson—that thrust surfaces and imbricate structures are seen to plunge deeply. In the Isfahanides and Cicatrice Zone, thrusting and folding occurs outwards towards the N-NE as well as to the S-SW, giving rise to a very large-scale fan-shaped structural style.

If the tectonics are to be explained by upward and outward squeezings due to motion towards the Foreland and Zwischengebirge, then the structures observed would be in order. This squeezing affect could have given rise to an initial intumescence or geotumor which created the necessary elevation required for tectonique d'écoulement to operate. In our area, the NE edge of the Iranides and Isfahanides-Cicatrice Zone lie some 90-200 km distant, which would involve a lengthy trajectory for the gravity-sliding surfaces. (Cf. 40-60 km proposed for the Alps of Europe.) This would require either initially great orogenic height, a high degree of plasticity of the gliding masses or then a pronounced concavity and asymmetry of the gliding surfaces. (Scheidegger's [1958] criticism of the angle of inclination postulated by Haarmann in his Undation Theory, viz. about 6° by stating « that high mountains with a slope angle of much more than 6° can persist for a long time... pretty well obviates the possibility of much sliding due to gravity occurring over slopes with such small inclinations» fails to take into consideration the physical characteristics of the rock masses (competency, incompetency, plasticity, slow creep, etc.). Further, as Goguel (1950) has shown, the larger the masses involved, the smaller the slope of the gliding plane required.)

It is equally possible, of course, that the intumescent process incorporating basement material was accomplished along upward-divergent steeply dipping thrust planes, recognizable in the field in the Isfahanide

zone. Outward-directed tangential pressures, giving rise to fan-shaped mega-structures would produce relatively slightly inclined, shallow thrust planes along which mass movement in either a NE or SW direction could take place.

From a study of the Rowanduz-Lesser Zab region, combined with reconnaissance investigations in other parts of Iraq and more cursory observations in Iran, the « classical» conception of a one-sided orogen is difficult to accept. Equally dubious is the exclusive role given to tangential compression. In Northern Iraq fault-trough subsidence has certainly occurred and in the continuation of the Iranides and Border Folds into SE Turkey, blockfolding is characteristic. (Tromp, 1949) Further, in the many cross-sections which the author has studied of the oil-field belt of SW Iran, the pre-Asmari Limestone beds (Oligocene-Lower Miocene) show a type of deformation more consistent with vertically-operative mechanisms.

For other regions of SW Asia (Mitchell, 1957, Press) the writer claims that taphrogenesis and vertical movements have played an important part in the tectonic evolution, though he hesitates to adopt such extrems views as those of e. g. Beloussov (1956, 1958). Lateral movemente have been operative within the Zagros region, perhaps accountable by tectonique d'écoulement, perhaps due to horizontal mass movement along almost flat thrust planes. Directions of movement within the Zagros have been both towards the SW and NE. The varying roles, in Space and Time, of vertical and horizontal translations, folding and thrusting, outwards towards the Foreland or inwards towards the Zwischengebirge, resulted in the diversity of structural forms which lend the infinite have variety to the grandeur of these noble mountains.

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ADDENDUM

Since the preparation of the above MS, there has appeared the volume dealing with the stratigraphy of Iraq. (Iraq, by R. C. van Bellen, H. V. Dunnington, R. Wetzel and D. M. Morton. Lexique Stratigraphique International, Asie, Vol. 3, Fasc. 10 a, C. N. R. S., Paris). Therein are given data from the files of the Iraq Petroleum and Associated Companies which hitherto has not been available to the public at large.

System	Stage	Formation	Thickness (in m.)	Lithology (In order of prevalence)	Tectonic Zones: Autochthon	Transition	Allochthon I	II	III	IV
Miocene	Helvetian-Burdigalian	Chama Lst.	200	Limestone, Marl, Shale, Sandstone, Siltstone.		×	×			
	Probably	Chimera Series	900	Conglomerate, Gravel, Grit, Sandstone, Arkose. Shale, Mudstone, Siltstone, Clay.		×	×			
Oligocene	L. Miocene to L Eocene	Bastasten Series	1000	Conglomerate, Grit, Sandstone, Marl, Shale, Mudstone, Limestone, Acidic Volcanics.		×	×	×		
		Kona Koter Metamorphics	3750	Phyllites, Schist, Limestone, Basic and Ultra-Basic Intrusives and Extrusives.					×	×
Eocene	Danian to Ypresian	Endezah Lst.	180	Limestone, Shale, Marl, Clay.	×	×				
		Kewarta Group	650	Shale, Limestone, Sandstone, Conglomerate, Tuff, Lava, Slate.			×			
		Kolosh Fm.	600	Sandstone, Grit, Gravel, Conglomerate, Shale, Breccia, Marl.	×	×	×			
		Shahidan Shale	1400	Shale, Mudstone, Siltstone, Arkose, Limestone, Dolomite.			×	×		
		Wasan Extrusives	1500	Lava, Agglomerate, Tuff, Mudstone, Shale, Chert Limestone, Siliceous and Calcareous Concretions				×		
		Popadar Extrusives	3500	Ditto, plus Acidic and Basic Dykes and Sills and small Acidic Intrusives.				×		
		Beshir Extrusives	2700	Ditto, plus Basic and Ultra-Basic Intrusives.				×		
		Walza Met. Series	3500	Schist, Marble, Calc-Schists, Gneiss, Aggomerate, Conglomerate, Sandstone, Phyllite.					×	×
		Marapasta Met. Series	2500	Phyllite, Schist, Marble, Quartzite, Hornfels, Greywacke, Limestone, Gneiss, Calc-Schists.					×	×
		Hero Met. Series	4000	Gneiss, Schist, Phyllite, Slate, Marble, Limestone, Serpentine, Granite, Granodiorite, Norite, Gabbro					×	×
Cretaceous	Maestrichtian	Tangero Fm	300	Shale, Marl, Sandstone, Siltstone, Grit, Conglomerate.	×	×	×			
	Campanian	Shiranish Marl	500	Marl, Limestone, Dolomitic Limestone, Shale, Clay.	×	×				
	Turonian	Kometan Lst.	1200	Limestone, Dolomitic Limestone, Dolomite, Marl.	×					
	Cenomanian	Qamchuqa Lst.	500	Limestone, Dolomitic Limestone, Dolomite, Marl, Shale, Mudstone.	×	×				
	Aptian	Sarmord Fm.	800	Limestone, Dolomitic Limestone, Shale, Clay, Siltstone, Sandstone.	×					
Jurassic	Barremian-Kimmeridgian	Chia Gara Fm.	150	Dolomite, Dolomitic Limestone, Limestone, Marl.	×					
	Kimmeridgian-Lusitanian	Barsaran Fm.	25	Dolomite, with Shale intercalations.	×					
		Naokelakan Fm.	40	Limestone, Marl, Dolomite, Clay intercalations.	×					
	Bathonian-Aalenian	Sargelu Fm.	35	Marl, Dolomite, Dolomitic Limestone.	×					
	Lias	Sekhanian Fm.	300	Dolomite, Dolomitic Limestone.	×					
		Sarki Fm.	250	Limestone, Gypsum, Anhydrite, Shale.	×					

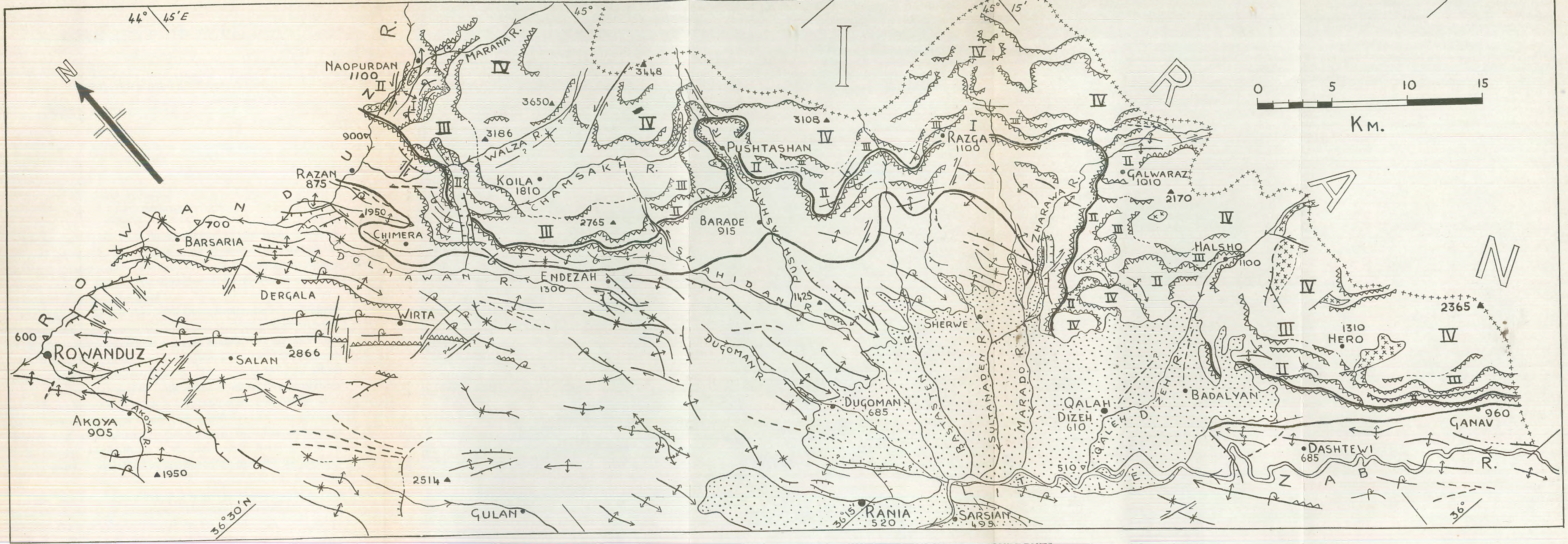
Fig. 3. Stratigraphic — Lithologic — Tectonic Chart.

As per the above volume, stratigraphic amendments are as follows :

Chama Limestone .... Name obsolete. Now named the Govanda Limestone. Inferred Burdigalian age. Type section thickness — 122 m.

Kolosh Formation	Palaeocene. Type section thickness, 777 m.
Tangero Formation..........	Tangero Clastic Formation. Upper Senonian (Maestrichtian to late U. Campanian. Type section thickness, 2018 m.).
Shiranish Marl	Shiranish Formation. Upper Senonian (Maestrichtian to U. Campanian?) Type section thickness, 227 m.
Kometan Limestone..	Kometan Formation. Turonian. Type section thickness, 36 m.
Qamchuqa Limestone........	Qamchuqa Limestone Formation. Hauterivian-Albanian. Type section thickness, 799 m.
Sarmord Formation	Valangian-Aptian. Type section thickness, 455 m.
Chia Gara Formation..	Middle Tithonian-Berriasian. Type section thickness, 232 m.
Barsaran Formation..	Barsarin Formation. Kimmeridgian? — possibly lower or middle. Type section thickness, 17 m.
Naokelakan Formation........	Naokelekan Formation. U. Jurassic — possibly Callovian-Argovian. Type section thickness, 14 m.
Sargelu Formation	Uppermost Lias-Bathonian. Type section thickness, 115 m.
Sekhanian Formation	Sehkaniyan Formation. Lias-probably upper. Type section thickness, 180 m.
Sarki Formation	Lias-possibly including part-Rhaetic. Type section thickness, 303 m.

STRUCTURAL MAP



ANTICLINE

SYNCLINE

OVERTURNED AND RECUMBENT FOLDS

NORMAL OR GRAVITY FAULT

WRENCH OR STRIKE SLIP FAULT

THRUST OR REVERSE FAULT

FAULT

LIMITS OF TECTONIC ZONES

I, II, THRUST UNITS OF THE ALLOCTHONE

LARGER INTRUSIVE MASSES

ALLUVIUM

RIVERS

ELEVATIONS, IN M.

+ + + FRONTIER

DEVELOPMENT OF SETTLEMENT
IN THE
SYRO-LEBANESE COAST
A STUDY IN HISTORICAL GEOGRAPHY

BY

M. E.-S. GHALLAB

I. INTRODUCTORY

This is an attempt to study the development of settlements as features of human activities in their relation to the physical environment on the one hand and as a result of the fuse of cultural elements of the Eastern Mediterranean as they manifest themselves in the Phoenician coast and its hinterland on the other hand.

The village was the first phase of human agglomeration in the Neolithic Age when man first acquired the art of food production mainly through cereal culture and domestication of hoofed animals. On the other hand towns first appeared in the Bronze Age, i. e. about the third millenium B. C. in the Eastern Mediterranean [1]. The town is the place where people concerning themselves with activities other than agriculture abide. It may not exceed a village in size, but it differs from it in function. Its residents are no longer farmers; or agriculture is no more the main occupation of its inhabitants. The town-folk are orientated towards trade, industry, administration or the professions. Moreover the town was the centre of administration and the ruling-class and the centre of

[1] Vide, Childe, V. G. What Happened in History, London 1944, ch. Man Makes Himself, 1936, pp. 119 et seq., The Bronze Age Cambridge 1933, and the Urban Revolution, *Town Planning Review* 21, 1950.

divinity as well in ancient times. This does not mean that the town is totally separated from its environment, for its people are dependent on the farm. Indeed, examples of ancient towns which were situated in non-agricultural regions are so rare that it may be safe to deduce that ancient towns originated as agricultural settlements and for some reason — historical, strategical or other — became centres of government and foci for human activities [1].

It seems highly probable from the *tells* excavated in Syria, Lebanon, Palestine and other Near Eastern countries, with very few and later, i. e. Iron Age and after examples that ancient « cities » were very diminutive in size [2]. The term « city » then, is only attributed for the function of the settlement. As the country was cut off by river, wadi and mountain, local differences had a tendency to be emphasized, thus leading to the splitting up of the country into autonomous principalities or kinglets, of which numerous « cities » were the capitals. The Canaanitic city was the site of government, where the « lord » of the principality ruled, the sanctuary of the local gods, and the fortress where the local inhabitants of surrounding villages and hamlets find refuge in time of emergency. The city itself—in general—occupied a dominating place in its environs, a prominence of land on the plain or a spur of mountain in the plateau, and it was—as a rule—surrounded by a wall. On one side of the city stood the palace (of the lord), on the other, usually the weakest part in fortification, stood the castle and in its middle the « high place » or the temple. Apart from these three functionary buildings, there was no kind of planning attempted, the houses were crammed into the limited area of the city in a complete anarchy [3]. The defensive requirements being satisfied, the Canaanites looked for other important requirements the watersupply and fertility of environs. Nearly all ancient sites were founded

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(1) Barrois, A. G. Manuel d'Archéologie Biblique, t. I, Paris 1939 p. 89, and Vincent, L. H. Canaan d'après l'exploration récente, Paris 1907, pp. 23 et seq.

(2) Vide for example Taylor, G. Urban Geography, London, and Samailes, A. The Geography of Towns, *Hutch. Univ. Lib.* London 1935, ch. I.

(3) Cf. Frankfurt, H. Town-planning in Ancient Mesopotamia, *Town Planning Review,* 21, 1950.

near some sort or another of water resources, springs, wells or an intermittent turbulent wadi. One feature of the Canaanitic city was the tunnel conveying water from a spring, pool or underground current from a cavern to the city. Later bottleshaped cisterns and aqueducts were used to store rainfall water [1].

Syria was an important urban centre in ancient times. Cities and towns were not only numerous, but differentiated and specialized in function as well. Trade centres, fortified cities and holy places; these were the main types of cities in Syria which could be traced back to the Bronze Age. The Phoenician coast was distinguished by abundance of harbours which paved the way to the rise of great ports which played an important role in ancient history. Thus the urban centres of the Phoenician coast and its hinterland can be classified into : maritime harbours or port-cities, trade centres and holy towns (Pl. I).

This classification is best understood in their relation to the physical environment. In fact elements of physical geography, i. e. configuration of the country and its natural vegetation divide it into major physical regions; namely the Phoenician coast, the maritime ranges, the central depressions, the inland ranges and the eastern steppe plains. These units run generally from north to south and succeed each other respectively from west to east. In addition there is the major region of northern Syria or the Syrian [2] Saddle which extends east-westwards.

Plains and lowlands attracted early settlement and thus became the first main centres of population and the first urban nuclei as well. The most ancient cities of the Eastern Mediterranean, and indeed some of the most ancient cities of the world first sprang on the Phoenician coast, in the central depressions and the desert and steppe fringe of the Syrian Saddle. A note must be added in interpretation of the geographical orientation of the main regions of Syria. The Phoenician coast

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(1) Cf. Masterman, E. M. G. Palestine Exploration F. Quart, S. 1934, p. 142 and Vincent, L. H. *op. cit.* p. 23 seq.

(2) Vide, Semple, E. C. The Geography of the Mediterranean Region and its Relations to Ancient History, London 1932, p. 184, and The Ancient Piedmont Route of Northern Mesopotamia, *Geog. Rev.* Vol. VII, 1919, pp. 153-179.

was in the main orientated to other Aegean sphere of interest, trade and culture although it was originally a northern extension of the land of Canaan i.e. settled by an ancient Semitic stock. To the Aegean influence, however, is related the origin of ancient harbours which became later the Phoenician cities, and were in fact orientated to the sea. Two ancient urban centres are notable examples of trade relations : Byblos or Gebal on the southern part of the coast and Ugarit, Ras Shamra on the northern part. The former was more or less Egyptianized and the latter cosmopolitan where Aegean, Semitic and Early Hittite influences mingled [1].

The central lowlands or depressions, the northern extensions of the Rift Valley which were mainly occupied with water courses, were in fact in the main thorough-fare of the ancient trade between the Nile Delta and Mesopotamia; hence the rise of trade-centres. The Beqaa was also the main gap through which Semitic migrations and invasions penetrated into Syria from the north and north-east. In the midland depression or Coele-Syria as a result pooled diverse ethnological elements : the Hittites, the Huri, the Mitani as well as the Semitic Amorites and Arameans [2]. The two main types of the Baqaa were : the metropolitan trade-centres and the feudal capitals of the local Amorite and Aramean princes.

The eastern plains were a transitional region between the sown in the west and the true desert further east. Hence it was a natural region for urban settlement of a certain type, the meeting place of the nomad, the destination of the desert caravans. In fact they can be relegated as

(1) Vide, Conteneau, G. Les civilisations anciennes du Proche Orient, Paris 1949, Dussand, R. Les Civilisations Préhelléniques dans le Bassin de la Mer Égée, Paris, 1923, Trans. to Eng. and Ghallab E-S. Some New lights on the Origin of the Phoenician Civilisation, *Bull. de la Soc. de Géog. d'Égypte,* t. XXXI, 1958, pp. 93-114.

(2) Vide, Albright, W. F. Western Asia in the Twentieth Century B. C. The Archives of Man, *Bull. Amer. Sch. Orient. Res.* N. 67, 1937, p. 27. Breasted, J. Ancient Times, *A History of the Early World,* New York, ed. 1944. Hogarth, E. G. The Hittites of Asia Minor, *Camb. Anc. Hist.* vol. II, 1931, pp. 252-272. Hitti, P. K. History of Syria, New York, 1951.

desert harbours, recipients of trade coming along the desert in exchange of Syrian and sea-borne trade as well. These desert ports were thoroughly Semitic in origin and development.

The northern plains region was also a transitional zone for the great traffic between east and west. This zone does not exceed 150 miles between the Mediterranean coast at Iskandarun Gulf and the Euphrates, the Syrian Saddle as some early writers called it. Through this strip of land the Mediterranean trade flowed to the Persian Gulf and the Far East. This region is clement in climate, receiving no less than 8 inches of rainfall a year, which is quite sufficient for a good grazing ground for caravan routes. Last but not least, this region was at the meeting place of diversified cultural and ethnological elements. Its towns were trade-centres, emporia and strongholds, fortified towns with castles and fortresses to safeguard the trade traffic between east and west [1].

The names of the Syrian cities and the Phoenician ports are presented in the historical documents of the 2nd. and 1st. millenia B. C., such as the Tell-el-Amarna letters, Bughas-Kuei tablets (about 14th. cent. B. C.) and the Old Testament (from the 10th. to the 1st. cent. B. C.) as well as the History of Herodotus (c. 468 B. C.), Theodore of Sicily (c. 90 A. D.) the Natural History of Pliny (23-79 A. D.) and the Geography of Strabon (c. 64 B. C.-19. A. D.). Although the scope of this paper terminates at the 8th. cent. A. D. yet many a Phoenician city had continued its activities well into the Graeco-Roman Period, and moreover had influenced the new phase of Hellenization of the Syrian coast. We might be aware that such cities as Laodicia (Latakia), Tripoli, Apamea (on the Orontes), Baalbek and the Decapolis were new foundations of the Greek or Hellenistic period. Some of these cities had vigorous growth and attained prominence among the new metropolies, and some eventually dwindled and passed away.

Villages, which are the most ancient phase of settlement and in some respects the more deeply rooted were not so fortunate as to be recognized in historical documents and chronicles. This presents some difficulty

(1) Cf. Semple, E. C. 1919, *op. cit.* and Woolley, L. Syria as the Gateway between East and West, *Geog. Journ.* Vol. 107, 1946, pp. 179-190.

in its historico-geographical study. Presumably, the geographical conditions did not undertake essential or fundamental alterations, and village sites, especially in the semi-arid regions, cling on the same response to the environment.

Syria was so influenced by diverse cultures that its place-names, especially in the country, could be recognized as probably the remnants of the past; relics of the passing armies, the influx of migrations and infiltration of cultural traits at different periods throughout its long history. Diverse ethnic groups left their deeply stamped influence on the place-names of hamlets, villages and cities, hence the wealth of Canaanitic, Aramean as well as Greek names of rural settlements in Syria and the Lebanon. Some of these names were adopted so as to give a modern Arabic guise [1].

II. GEOGRAPHICAL FACTORS CONTROLLING THE CHOICE OF RURAL AND URBAN SITES

The main geographical factors controlling the choice of rural and urban sites are : relief, soil, water-supply and climate. These factors were interrelated in the choice of different localities with varying emphasis. Some factor might have attained certain prominence at a certain time, and some might have played but a minor part. For example relief was a dominant factor in controlling the location of villages and towns on the slopes and terraces of the Lebanon mountains. Human habitation preferred sunny sheltered slopes but sometimes facing the sea was preferable. Whereas in the Eastern Lebanon, the Qalamun ranges and Djebel el Sheikh valley mouths were chosen as sites for villages and townships, in the Western Lebanon mountains they were avoided lest such settlement should be washed down by torrential streams flooded after heavy winter rainfall or by ice melt water in early spring [2].

[1] راجع فريحة ، أنيس : أسماء القرى والمدن اللبنانية جونية ، لبنان ، ١٩٥٦ ص ١٩ .
FREIHA, A. Place-names in the Lebanon 1956, In Arabic.

[2] Cf. WEULERSSE, G. Paysans de Syrie et Proche Orient, Paris 1946, and THOUMIN, R. La Géographie du Liban Central, Paris 1936, pp. 296 et seq.

Villages were carefully sited near fertile patches of land where convenient slope permits cultivation. Such fertile pieces were so valuable that people could not afford to build their settlement on them; they moved on rocky slopes nearby. Many a village in the Lebanon is sited on mountain shoulders and backs called «duhur» where more than a purpose was fulfilled especially security on a prominent place where villagers can overlook any hostile approach and utilisation of gentle slope where agriculture is possible [1].

Village folks who are usually the oldest element of population prefer security (much needed and sought for especially during times of disorder and unrest) on high rugged slopes. They tend to choose their settlement on the «back» duhur of the mountains or in amphitheatre-like spurs overlooking snake-like mountain tracks or even strategic points on precipitous rocks. The Lebanon was decidedly a region of refuge. Towns on the other hand were sited in the plains on main trade-routes which cross the country from the south to the north, as a link in the great trade-route between the Nile Valley and Mesopotamia. Main urban centres were thus distributed along three main strips of zones running from south to north and aligned successively from west to east, according to the general configuration of the country. These main urban zones are : the Phoenician city-ports and harbours, the Beqaa cities and the desert-fringe oasis-like or «ghuta» cities. To these may be added a fourth zone, the saddle—like east—westwards cities of northern Syria. The former three zones are separated from each other by mountain faulted ridges which form formidable barriers to east-west communications. However these ridges were faulted in some places by transversal faults, which provided natural gaps crossing the mountain barriers. Main communication lines between the Mediterranean coast and its hinterland follow these natural gaps besides some minor difficult to cross lines.

The distribution of underground water-supply which emerges as springs or can be dug for easily, is a decisive fact in the choice of village and town sites in a region which suffer from arid long summers. Such

[1] THOUMIN, R. Loc. cit.

springs occur along longitudinal or north to south major fault lines and transversal or east to west minor fault lines as well in Syria and the Lebanon [1]. Settlements are small, numerous and scattered where springs are abundant but people tend to agglomerate in large settlements where springs are few and far between. The latter is specially the case of town-like settlements which are in fact nothing more than enlarged villages on the desert fringe.

Settlement, then, in our region can be classified as follows :

1. The Phoenician city-ports.
2. The western Lebanon mountain settlements.
3. The Beqaa trade and fortified cities.
4. The desert fringe oasis cities or desert harbours.
5. The north Syrian cities.

III. THE PHOENICIAN PORT-CITIES

The Phoenician coast stretches from Kara Doran in the north to Ras en-Naquora in the south for almost 300 miles as the crow flies. This coast is far from being physically homogeneous in all its parts, as several kinds of coasts are represented in it. High steep cliffs showing effects of wave-erosion north of Latakia, indented shore from Tripoli to Beirut, a sandy stretch of coast near Tyre, sand-dunes north of Djeble and projecting rocks, promontories and stoney islets near the coast in some other parts.

The coast is nearly barred from the interior by these mountain blocks : Amanus in the north, Nassyria or Alouite in the middle and the western Lebanon in the south. Two natural routes from the coast to the inland cross the coastal highlands ; Antioch and Gisr el Shughur bridge on the one hand and Tripoli-Homs gap on the other.

The coastal highlands differ from each other in structure and relief and in turn their control on the inter-course between the coast and its

[1] Vide, Dubertret, L. L'Hydrologie et Aperçu sur l'hydrologie de la Syrie et du Liban dans leurs relations avec la Géologie, *Rev. de Géogr. Phy. et de Géol. Dyn.*, pp. 347-531, Cartes Lithologiques de la Bordure Orientale de la Méditerranée, Beyrouth, 1943 ; and Fisher 1945.

hinterland, the extent to which the coast is dependent on the hinterland and ultimately the cultural orientation of the coast itself differ as well. All these factors combine to shape the characteristics of human settlements, be it a village, town or port. Thus it may be convenient to sub-divide the Syrian coast into three sections, according to the coastal highlands which overlook it and in some degree separate it from the hinterland. These sections which will be studied in turn are : *a*) from Iskandarun to Ras el Khinzir, *b*) from Ras el Khinzir to Tripoli, and *c*) from Tripoli to Tyre. (Fig. 1).

From Iskandarun to Ras el Khinzir the coast lies at the foothills of Amanus, Kizil Dagh and Cassius mountains. The shore profile is diversified by irregularities due to differences in rock hardness of the folded mountains with intrusive rocks. Igneous rocks look barren as they cover mount Cassius. Nevertheless there are some pines scattered here and there. The coastal ranges did not lack wood resources which characterised the Phoenician coast altogether. However these highlands are poorly endowed with good soil, cut but with few valleys where cultivation can hardly sustain settlement of any considerable size. It has never been attractive to settlement. Nevertheless there are some passes which cut through these highlands and so rendered it possible for the interior depression of ʿAmq to penetrate to the coast, and thence to Cilicia and Asia Minor routes beyond. Thus this section of the coast could be of some use and gave rise to some harbours which could be utilised by both Asia Minor and northern Syria.

The Geographical position of this section over-weighs its physical properies in determining its importance as suitable urban centre. This was a region of transition between the Semitic world in the south and the Hittite and later the Hellenized world in the north. The coast, moreover, has a reputable hinterland of old established commercial community which carried on trade enterprises between the Persian Gulf and the Mediterranean. Thus this section of the coast naturally played the role of maritime outlet of the commerce of Antioch, Aleppo and beyond up to Naharin [1].

[1] Woolley, L., *op. cit.* pp. 179-190.

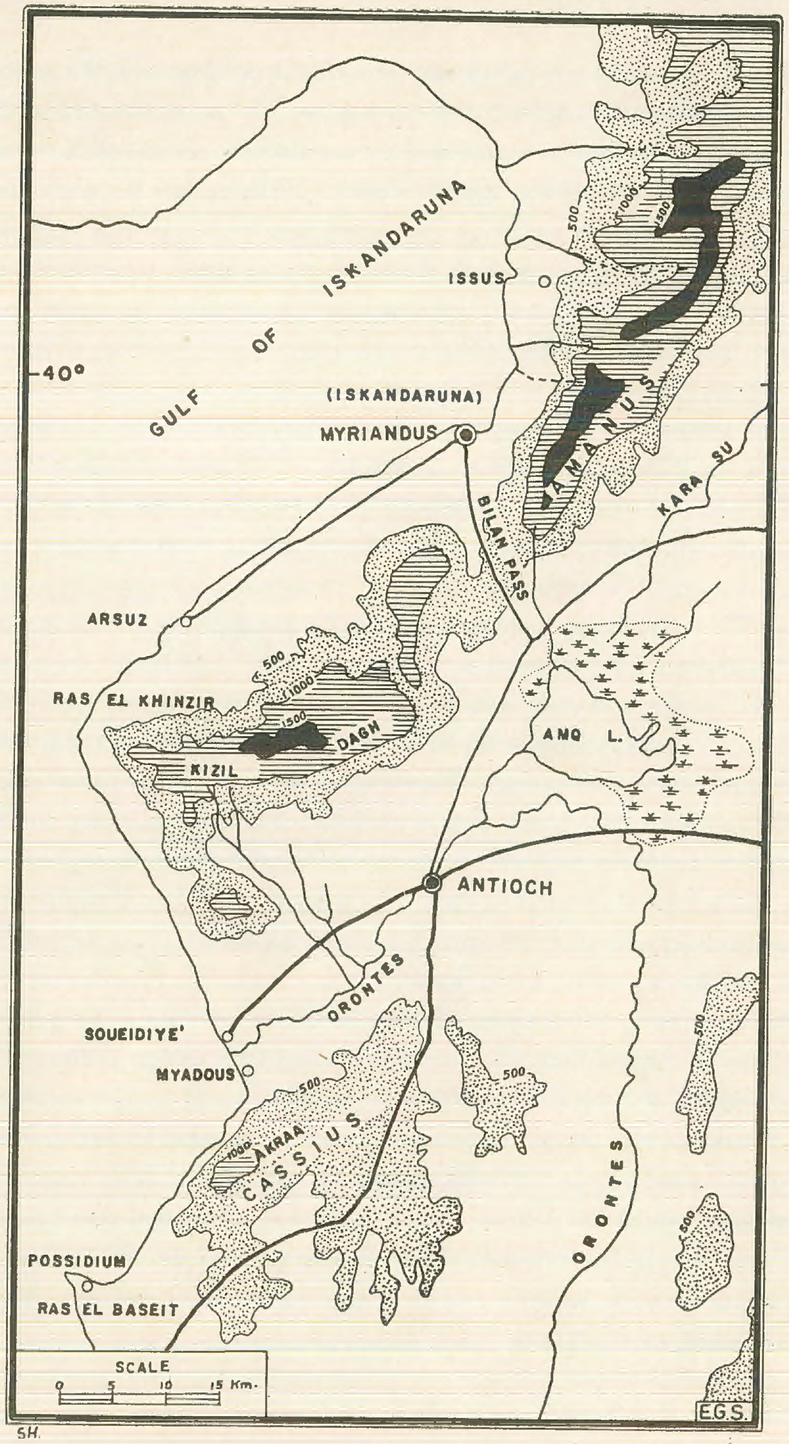

Fig. 1. Northern Sector of the Syrian Coast.

It was expected to find in this section of the coast remains of an ancient maritime people as the Phoenicians had been. Archaeologists, however, could not find the remains of ancient Myriandus which is mentioned in classical records. However, it seems likely that it was the predecessor of the modern Iskandarun, or a little further inland, so that it might control the route which passes by it.

South of Iskandarun, the coastal plain becomes wide again, until it reaches Ras el Khenzir. Kizil Dagh or the Red mountain which is covered with pine and cedar overlooks this part of the coast, which yields remains of some few ancient harbours of the Graeco-Roman period. Irsuz, Issus and Alexandretta (modern Iskandarun) arose when *Pax Romana* dominated where it was not safe formerly to establish a Phoenician settlement [1].

From Ras el Khinzir to Tripoli the coast stretches more or less straightly and consists largely of very few shingly bays, low cliffs and sandy beaches. The coastal plain is narrow, bordered with sand-dunes but now and then emerge narrow strips of intense cultivation, except at Tripoli and Akkar where the coastal plain is quite wide, rich with ample water-supply emerging from springs and flowing seasonally in small torrential streams, hence its wealth in wheat, vine olive trees which characteristically form a feature of the environs round Tripoli. Nassyrieh mountains bordered with bold longitudinal fault stand sheer from the coastal plain as a formidable barrier rarely with a feasible hinterland route into the interior. Access to the hinterland was however possible by going round the Nassyrieh block from the north or the south, where the highlands are gently sloped and easy to cross. Two major routes link the coast at this section with the hinterland : Hama-Masyaf-Banyas route across the mountain block and the much easier Homs-Tripoli route. It was not difficult for any state in Syria Coele with its capital based on the Orontes to penetrate into the coast at this section. Perhaps this was likely the reason why the

[1] Cf. Woolley, L. *op. cit.* p. 182 et seq. Posidium was a small harbour at Ras el Bassite during the Graeco-Roman times. Vide, Dussaud, R. Topographie Historique de la Syrie Antique et Mediévale, Paris 1927, *Bib. Arch. Hist.* V. IV, p. 418.

Phoenicians ventured to establish only one port-city on this section, characteristically on an islet at some distance from the shore. Indeed this was not a busy Phoenician settlement region. (Fig. 2).

The settlement of this part of the coast goes back to the time of Tell-el-Amarna letters, i. e. the 2nd. millenium B. C. as some harbours and fishing villages arose. Some surviving villages still bear witness to this ancient settlement, such as : Symira, Ullaza (Orthsia?), Magaliun and Amki (unidentified as yet) and, Sheglata (which might have been el-Chakka) and Urkara (modern Arqa) [1].

Samyra attained a distinguished place during the period between the fifteenth and twelfth centuries B. C. as a seat of Egyptian rule [2]. After the eclipse of Egyptian sovereignity over Syria it soon lost its former position as an independent city and was eventually drawn to the orbit of the developing Arwad.

Arwad was the chief Phoenician port-city of this section. It was indeed the only port-city which the Phoenicians ventured to establish in such an exposed portion of the coast, an outpost at a distance of their secure isolated home. At a dangerous proximity to Hittite realm at the Orontes, it had to be built dramatically on an offshore islet [3]. Its rock was indeed handicapped by several disadvantages being barren bare of any soil and moreover without a natural harbour. Phoenician skillful art and sense of maritime enterprise helped to connect the islet with the surrounding minor rocks; they also built an artificial wave bar about the middle of its eastern side and thus created two harbours facing the mainland. Arwad eventually became a fort where the Phoenicians could find refuge in an islet, housing a commercial community and harbouring a big trading fleet. It is noteworthy that Arwad in its place of refuge was the last Phoenician city to fall at the hands of hostile attacks as it could stand long sieges. The port-city on the other hand was dependent on sustaining villages which provided its commercial community with food, water and

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(1) Dussaud, R., *op. cit.*, p. 117 and Weber, O., Die El-Amarna Taflen, p. 1156, note 1.

(2) *Ibid* and Weber, O., *op. cit.* 1138, also Maspero, Histoire Ancienne, t. II, p. 172.

(3) *Revue Biblique,* 1907, I, p. 333 et suiv.; *Syria,* 1925, p. 269.

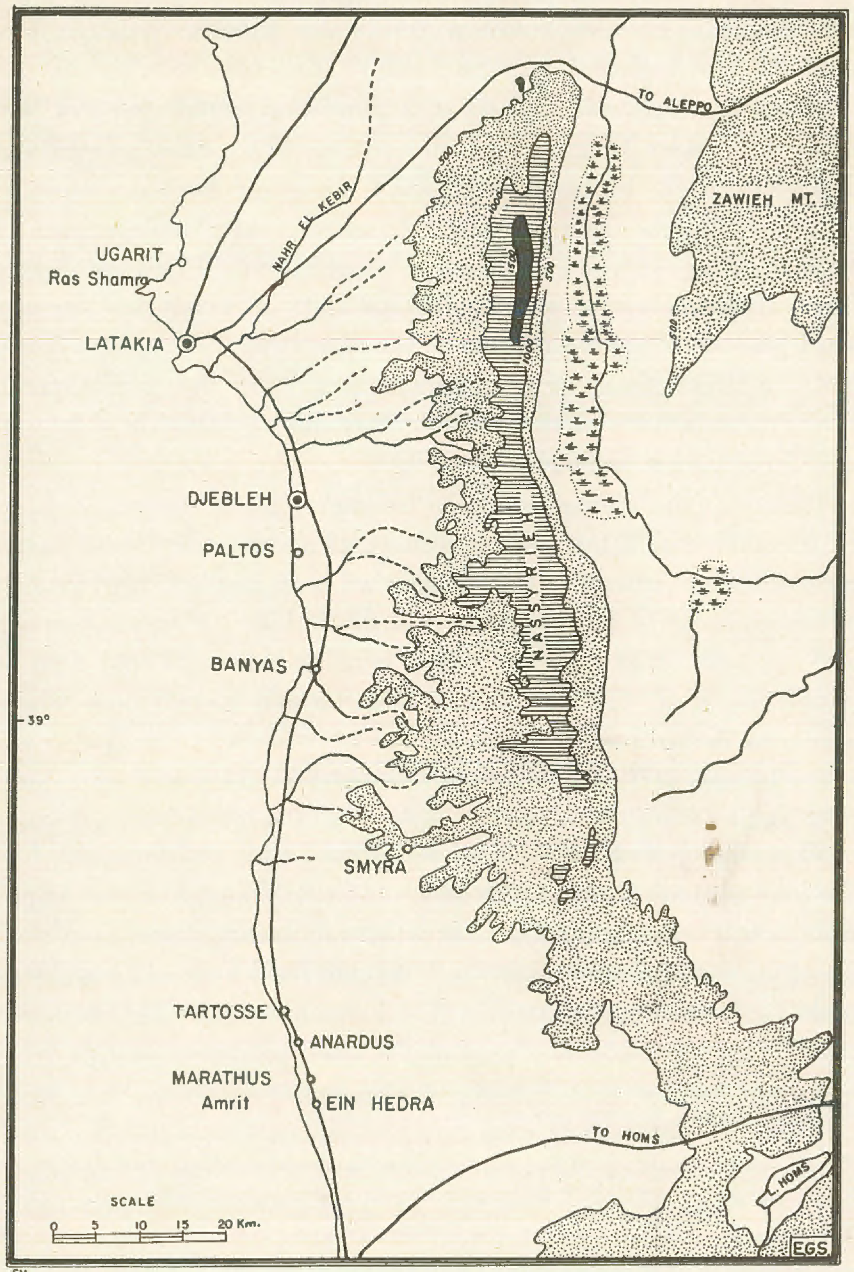

Fig. 2. Southern Sector of the Syrian Coast.

other provisions. Chief among such villages were Ein Hedra (modern Tell Ghamqa), Marathus (modern Amrit) and Antardus (modern Tartosse) [1].

Arwad, it seems, was a centre of a flourishing settlement near and about it. Besides Antardus (or mainland Arwad) the small villages and dependencies on the coast, many small towns and harbours arose as subsidiaries to the main port-city. Dussand could identify a score of small townships in the environs or orbit of Arwad. These towns were Banyas in the midway between Latakia and Tartosse, with a small harbour which could be of use to the route crossing Nassyrieh mountains to Homs. North to Banyas some springs emerge and give rise to a small stream, River Sin, on which a small town with a harbour was founded. The town itself recalls Greek prominence [2].

Although Tripoli occupies now a prominent place among Levantine cities, yet it was quite insignificant during the Phoenician age. Nevertheless some settlement must have been established in its location about the first millenium B. C. [3]. Its old quarter near the harbour still bears the stamp of Phoenician cities : narrow streets winding between crowded many storied buildings. Two temples of Ashtart (or Ashtoreth) and Adonis were excavated in this old quarter.

The location of Tripoli is naturally destined for the rise of a city-port. It is endowed with a natural harbour which securely lies between a small cape projecting into the sea and a fairly wide and protected bay. The coast is endowed with a fairly wide and fertile plain, Akkar and Tripoli plain, which could sustain a sizeable urban population. Tripoli, moreover lies at the end of a natural gap which is transversed by an old established trade route, linking Syria Coele and beyond with the Mediterranean coast. This easy access and proximity to small potentates in Syria Coele

[1] Renan, E. Mission de Phénicie, Paris 1860, p. 59 et suiv. Hill, G. F. Brit. Mus. Cat. Phoenicia, p. XI et suiv.; L'ère de Marathus, *Jour. Arch.* 1899; et Renan, *op. cit.* 97; also cf. Rawlinson, G. History of Phoenicia, 1882, pp. 73-74; Newbigin, M. I. The Lands of the Mediterraneans, pp. 109-112.

[2] Dussaud R. Top. *op. cit.*, p. 128 and p. 132, 136.

[3] Cf. Hill, G. Brit. Mus. Cat. Phoenicia, p. cxvi, ff. Maspero, His. Anc. II, p. 172.

and the hinterland rendered it unwise for the Phoenicians to risk a city in this place. Such was the reason why the site of Tripoli had to wait until peace and security prevailed in a united Syria during the Graeco-Roman times and after.

The Phoenicians, nevertheless, had fortified defence posts in the plain of Akkar to be able to stand any sudden attack from the interior. Orthosia was another maritime city which like Tripoli did not flourish until the last two centuries B. C. Its ruins are still scattered at the left side of Nahr Barid where inscriptions of Ashtart, Baal, El and Ashmun Baala were found [1]. These are clear evidence that the peoples were of the same Semitic stock which settled in the country early in the third millenium B. C. Ullaza, often mentioned in Tell El Amarna letters which was probably the latter Greek Orthosia, was a small town during the second millenium B. C. [2]. Other small villages in the plain still bear evidence to Semitic antiquity. Persistence and continuity of such settlements like Arka and Shin [3], with oscillating phases of flourishing and decline characterize ancient settlements of the coast. (Fig. 3).

From east-north-east to west-south-west stretches the southern section of the coast studded with capes and rocky islets and deep harbours and backed by great elongated, faulted domes forming the coastal mountains, and leaving no division which could be called physiographic coastal plain. Whereas the chief promontories south of Tripoli are utilised by Beirut and Haifa, there are several minor caps and promontories such as cape Batrun, Ras el Chakka and Ras en-Naqura beside many small rocky islets which were separated from Ras el Chakka by marine erosion and the rocky islet on which Tyre was originally built.

The Lebanon mountain overlooks the shore directly in some places; its foothills are washed by the sea, where it projects into it in vertical abrupt steep slopes. South of Ras el Chakka the mountain slopes get gentler, leaving a narrow strip of coastal plain and as the anticline dips southward it becomes less high and eventually it is dissected into separate blocks : Djebel Amel and the Galilee Plateau.

[1] Renan, Mission etc., p. 116, also Dussaud R. top. p. 79.

[2] Barois, A. G. *op. cit.* 1939, t. I. pp. 89 et seq.

[3] Dussaud, R. top. p. 79 after Weber, O. *op. cit.* p. 1141. Genesis Chap. 10, 17.

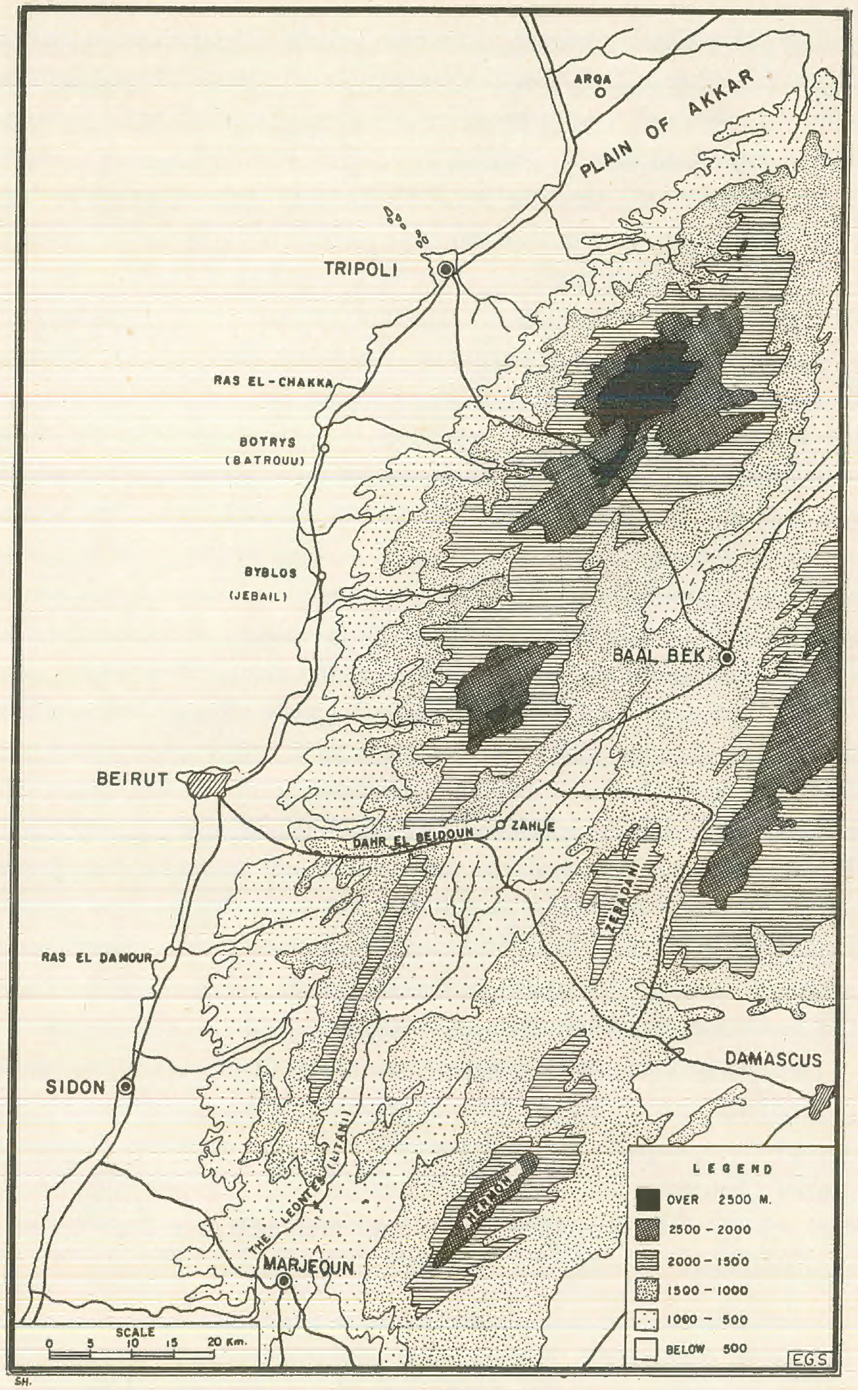

Fig. 3. Northern Sector of the Lebanese Coast.

The Lebanon highlands severe the Phoenician coast almost completely from the interior. This factor of isolation was so manifestly preferred to the factor of proximity to trade-routes that the Phoenicians sought refuge and security in their flourishing city-ports and were rarely directly affected by the vibrating interior. International highways and trade-routes between the Nile and the Euphrates avoided the Phoenician coast and the Semitic migrations did not penetrate the mountain barrier nor the Hittites at their hey days dominated it. Inter-course between the coast at this section and the interior was indeed very difficult as passes were few. The Beirut-Damascus route is indeed very recent, and had no importance during the Phoenician times. Sidon-Quneitra route was probably transversed during the last two centuries B. C., under the control of Sidon. The only initial opening nearby was utilised by the Galilee route between Acre-Safad-Quneitra and thence to Damascus. It was the only gap which links the Phoenician cities with their hinterland across the mountain. This access is dramatically far from being easy or direct and hence adding to the Phoenician security.

The Lebanon highlands were covered with cedar, pine, elm, beech, laurel, poplar, walnut, ash, cypruss and holly trees, that is with wood resources which Egypt and Mesopotamia drastically lack. To this wealth the rise of the first urban centre in the Syro-Lebanese coast was indebted. Byblos or Gebel which established regular connections and cultural intercourse with Egypt was in fact primarily engaged with wood trade [1]. Narrowness of the coastal plain, lack of ample arable land, absence of direct natural routes with the interior across the mountain barrier and lack of convenient land routes with other villages scattered at small bays, all these factors compelled the early inhabitants of Gebel and the Phoenician coast to seek fortune by coast-navigation and sea-faring.

Such were the physical association of factors which gave rise to an early navigating community which looked to maritime activity as the basis of its social and economic structure. Isolation from turmoil and probable interruptions of interior Syria, remoteness from imperial ambitions of

[1] Vide Montet, P. Byblos et l'Egypte, *Bib. Arc. Hist.* XI, 1920, pp. 285-292, also Ghallab M. E-S. 1958, *op. cit.* pp. 94-113.

both Egypt and Mesopotamia, aloofness from the repeated and rythmic Semitic migrations, helped to create a cradle for a maritime civilization. The physical habitat of the Phoenician coast provided it with safety and security needed for any civilization in its embryonic stage. Here, in our opinion, was the real home of the Phoenician civilization. Movers on the other hand tried to find it at the bay of Iskandarun while Shaeffer sought for it at Ugarit or Ras Shamra region [1]. The latter region was indeed an important link between the Aegean and northern Syria and Mesopotamia as well. It had to wait until the Graeco-Roman times to flourish again as an urban centre. Such a place at the cross-roads of peoples, trade and imperial armies was not likely to be a home for a new emerging civilization.

This southern section had the advantages of both aloofness of and proximity to the trade-centres of Syria. The Phoenician cities alone could dominate the few difficult trade-routes across the mountain barrier. Thus they could regulate their intercourse with the interior without being submerged or completely severed from it.

The Phoenician cities faced the problem of water-supply and food provisions. The Lebanon mountains are fringed with two longitudinal fault lines at both eastern and western sides. Springs emerge with ample water which originally percolates through dolomitic and calcareous strata of the mountains, and appear at the fault lines. Springs gave rise to numerous villages whose population were engaged in terrace building, horticulture and cereal cultivation. Moreover the coastal plain receives ample rainfall in winter. Some of the rainfall —as stated above —penetrate into the permeable rocks to feed springs or into the coastal plain which consists of lime and sand. As the general dip is seaward, the surface water table dips into the sea and water is thus easy to tap from the off-shore islets. The genuity of the Phoenicians enabled them to get water emerging under the sea-level at Arwad and Tyre.

[1] GHALLAB, *op. cit.* also CONTENEAU, G. La Civilisation Préhellénique dans le Bassin de la Mer Egée, 2nd. Paris 1914; SCHAEFFER Cl. F. Ugaritica, I, Paris 1939 and Stratigraphie comparée de Syrie, L'Asie Occidentale et Proche Orient, Oxford 1948, MOVERS, F. C. Vol. 2, pp. 170-174, cited by SEMPLE, E. 1932. *op. cit.*

Thus the city ports of the coast acquired their characteristic features. Several cities built over promontories and projecting rocks into the sea or on a rocky islet off the shore; securing a quiet harbour and backed by a mountain barrier keeping it safe and secure on one hand and providing it with wood resources for trade and building boats on the other. The port-cities were at once at a safety measure aloof from the turbulent interior and inter-related with its market-cities. They were well provided with food and provisions from the several flourishing villages at the foothill of the mountain.

This section then is the stronghold of the Phoenician thallasocracies, i. e. city-states which were inter-dependent in time of strife only. The Book of Genesis classifies them into the Sedonians or southern Phoenicians who include Tyre and Sidon and their coastal dependencies; the Arkites and Sinites, i.e. the inhabitants of Byblos and northern Lebanon and the northern Phoenicians or the people of Arwad [1].

The northern Phoenician cities were dealt with already. Now we turn to the harbours and cities which lie between Ras Tripoli and Ras Beirut. The earliest settlement in this section is Byblos, which can be also regarded as one of the most ancient urban centres in the world. It was settled by the early Canaanitic ancestors of the historical Phoenicians, who were later called the Giblites [2]. Byblos was first established on its little bay at the foothills of the cedar covered Lebanon in the 4th millenium B. C. It carried on trade with Egypt and persisted as a harbour with fluctuating periods of rise and fall until it was finally destroyed by the Crusades in late medieval times. In a previous paper by the present writer, reference was made to its prominent role during the Bronze Age. It is enough to add here that Byblos had a special significance as a religious centre for the rites of Isis and Osiris; and Ashtart and

[1] GENESIS, Ch. 10 and JOSUA, ch. 13. DUSSAUD, R. Byblos et la Mention des Giblites dans l'ancien Testament, *Syria* 1903, p. 314.

[2] Byblos is the Greek form of Phoenician Gebal or Gabal (Mount), also was mentioned Gubla in Tell-el-Amarna letters. The Ancient Egyptians inscribed its name as Keben or Kepen. Now it is called Jebail, and should be distinguished from Djeble between Latakia and Banyas. Cf. DUSSAUD, Top. *op. cit.* p. 63 note 5.

Adonis respectively [1]. Religious and spiritual association was a flavour often added to important urban centres in this part of the world as elsewhere in all time.

Byblos was the chief centre among many small towns and villages, most important of which were Botrys (modern Batrun and Beirut) [2]. The former arose at Ras el Chakka where the coastal road ascends at the foothill of a projecting block and then begins to descend again. At such a point merchants and travellers had to stop before proceeding to cross this col. Beirut was also one of the dependencies of Byblos. Its name first appeared in Tell-el-Amarna letters as Beeruta, derived from Hebrew Béerot (wells). Some writers claim that this place was early settled in the Neolithic Age, as a fishing village. (Fig. 4).

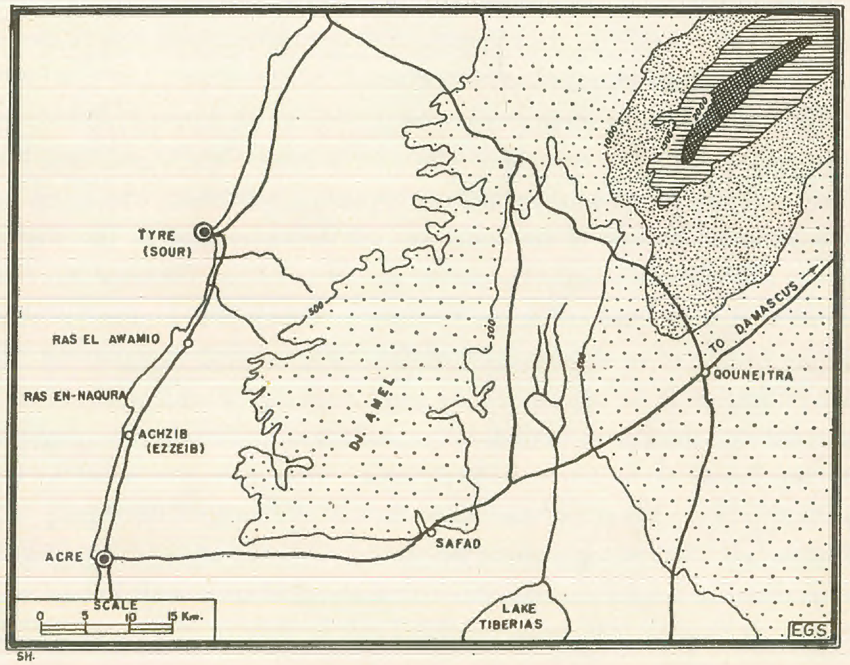

Fig. 4. Southern Sector of the Lebanese Coast.

[1] DUSSAUD, R. Top. *op. cit.*, p. 62 et seq., 69 et seq. MONTET, P. Syria, 1923, p. 334 and C. R. A. I. 1925, p. 52. DUSSAUD, R. Syria, 1924, p. 135; Syria, 1925, p. 105 and VIROLLEAUD, M. Syria, 1922, p. 273.

[2] RENAN, Mission etc., *op. cit.* p. 249 et seq. DUSSAUD, R. Top. p. 58.

At Beirut converge the coastal trade-route which follows the shore at three successive levels, the Egyptian and Assyrian road above, the Roman road in the middle and the modern lower still, and the highland road which crosses the Lebanon mountains at Sofar, Dahr Beidar and Zebadani to Damascus. The latter is the chief link between the Mediterranean and Damascus in modern times.

Sidon and Tyre were the two chief Phoenician port-cities in this portion of the coast. Sidon, surviving still, lies on a triangular projection of the land which tapers into the sea. Old quarters of the modern town still occupy the ancient site. It yielded rich and variant antiquities which could be dated from the third millenium until quite recently. During the Bronze Age Sidon was a mere village among thriving coastal ones. In the xth. century B.C. however, Canaanitic inscriptions found at Sidon distinguish between Sidon-Yam i. e. maritime Sidon and Sidon Sada or agricultural Sidon. Thus the city had a double function, a commercial port-city and a local agricultural centre [1].

Tyre, the chief rival of Sidon was built on a rocky islet near the mainland, at the southern end of the Lebanon Barrier. It excelled Sidon as a natural outlet for interior Damascus. Tyre boats carrying cargo from the sea met with caravan or desert ships carrying merchandise from the south and the east. Tyre was thus easily accessible for caravan leaders and could be at times an easy prey for intruders. This accounts for its island site which provided it with secure insularity. Tyre, like Arwad was the last Phoenician stronghold to fall to the enemy's hands. Alexander had to build a moat to get reach of this valuable prize [2].

[1] Vide for classical mention of Sidon Homer, II, VII, p. 290; XXII, 743. For archaeological records vide RENAN, Mission, *op. cit.*, p. 361; MACRIDY, Th. *Rev. Biblique*, 1902, p. 890; 1903, p. 360. Also CONTINEAU, G. *Syria*, 1920, p. 16, 108, 198; 287; *Syria*, 1923, p. 201; 1924, p. 123 and DUSSAUD, R. *Syria*, 1926, p. 1; DUSSAUD, R. Les Travaux et les Découvertes Archéologiques de Charles Clermont-Ganneau (1845-1923) *Syria*, 1923 pp. 140-173.

[2] Cf. RAWLINSON, History of Phoenicia, 1880, pp. 65 et seq.; NEWBIGIN, M. I. *op. cit.*, 1924, pp. 109 et seq. and FEDDEN, R. Syria, p. 69.

For the excavations and discoveries of ancient Tyre vide, POIDEBARD, A. Tyr : Un Grand Port Disparu, Paris, 1939. For the topography of ancient Tyre vide,

It can be infered from ancient records that Tyre was the most important port-city on the Levant for many centuries. Its commercial importance was already at its zenith during the reign of Nabuchdanazar 1120 B. C. Ezekiel described in some length its trade relations especially with Damascus [1]. Now, it is no more than a small harbour housing fishermen boats.

Although the history of Tyre goes back to the time of Tell-el-Amarna letters, it is not as ancient as Gebal, Byblos. Like Sidon, it played a double role, a chief agricultural centre and a port-city, the home of a commercial community with their interests bound to the masts of their ships.

The country round Tyre still bears witness to cultural relics of the past. The village of Tell-el-Mashuq (the beloved) for instance may remind us with the ancient Canaanitic diety of Adonis or Ashtart.

Last, but not least, Tyre was on the coastal road which links the Phoenician cities along the coast. It began from Acre to Achzib, a secondary Phoenician city, then it crosses Ras en-Naqura at a difficult climb, Scala Tyriorum to Ras el Awamid and henceforth along the coast to the north, passing by many small towns until Ras el Ein, Rashidia and Tyre. The small towns and villages still surviving are no doubt as old as the IXth century B. C.

Renan, Mission, pp. 527 et seq. De Le Lasseur (Mme), Syria 1922, pp. 1 et seq. Maspero, Hist. Anc. III, pp. 183 et seq. Cayeux, L., Géologie appliquée à l'Archéologie, Le Problème de l'Ancien Port de Tyr étudié à la lumière de la Petrographie, *C. A. S.* t. 207, n° 20, 14 Nov. 1938, pp. 881-884. Dussaud, R., *op. cit.* pp. 9-11, 18, 44 et seq.

[1] Ezekiel, Ch. 27.

Relief Plan of Lebanon (after a maquette made by l'École des Arts et Métiers de Beyrouth pour l'Exposition de New-York en 1939).

THE GEOLOGY AND GEOMORPHOLOGY

OF

EL QUSAIMA AREA

(NORTHEAST SINAI, EGYPT, U.A.R.)

BY

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ABSTRACT

El Qusaima area, located in the northeast corner of the Sinai peninsula, is occupied entirely by sedimentary rocks belonging to the Secondary, Tertiary and Quaternary eras. The surface exposures have a measured thickness of about 1700 m. of which 1400 m are of Cretaceous age. These are dominated by chalk and lime facies in the upper portion and by sand and clay facies of «Nubian character» in the lower portion. In this area, the succession representing the Tertiary and the Quaternary eras, mainly developed into chalks, marls and gravels, has a much reduced thickness, both due to nondeposition and to erosion. In El Qusaima area the landscape is affected by the strong belt of domal structures which crosses North Sinai in a NE-SW direction.

El Qusaima area hase reasonable soil and water potentialities, but these are not evaluated properly. It is, therefore, recommended to carry out a detailed soil survey as well as shallow test boring which should be preceeded in some places by a reconnaissance resistivity investigation. This exploratory work may lead to the gaining of about 100,000 acres of arid land in El Qusaima area.

INTRODUCTION

El Qusaima area, located in the northeast corner of the Sinai Peninsula, occupies an area of 2500 sq. Km. El Qusaima itself is a small beduin settlement and a frontier post lying in the eastern portion of that wide area. Nearest towns to this settlement are El-Arish and Rafaa which are located on the Mediterranean coast about 60 Km. to the north.

El Qusaima area is accessible by an asphalt road from El-Arish town and by a number of desert tracks from the other frontier posts occurring in East and Central Sinai; namely El Kuntella, Nekhl and Bir El Hassana.

The detailed study of the geology of El Qusaima area was done by the writer mainly in 1946 and 1947 during his work with the Standard Oil Company of Egypt. Some work was also done in 1951 when the Desert Institute of Egypt arranged a scientific expedition to North Eastern Sinai. In this study the plane table and the telescopic alidade were used in mapping and in measuring the thickness of the stratigraphic section. The topographic maps, on a scale of 1 : 100,000, made by the Survey Department (North Sinai Series), served as a reasonable accurate base for the construction of the present geologic map (Map 1).

Prior to this work, the standard geologic map available for El Qusaima area, is on a scale of 1 : 1,000,000 (Atlas of Egypt, 1928). This was reproduced from the original maps, on bigger scale, prepared by Moon and Sadek (approximately in 1921) during their work in North Sinai (this work was conducted by the Government as part of the research for petroleum; details of this work are not published yet). To show the position of our knowledge of the geology of this area before the commencent of our field work, a part of this map was traced on paper (Fig. No. 1). The following are our comments on the occurring geological information :

1. On this map, the distribution of the main rock units is carefully indicated. Also the major structural features are reasonably presented.

2. On this map, the eastern portion is occupied only by Middle Eocene strata, but the present investigation has shown that these are underlain by Lower Eocene flinty limestones and chalks, and then by Palaeocene gypseous marls and chalks. These are well preserved in the « Cuestas» of Gabal El Wogier, Gabal El Ein, Gabal El Abyad, Gabal Umm Hereiba ... etc.

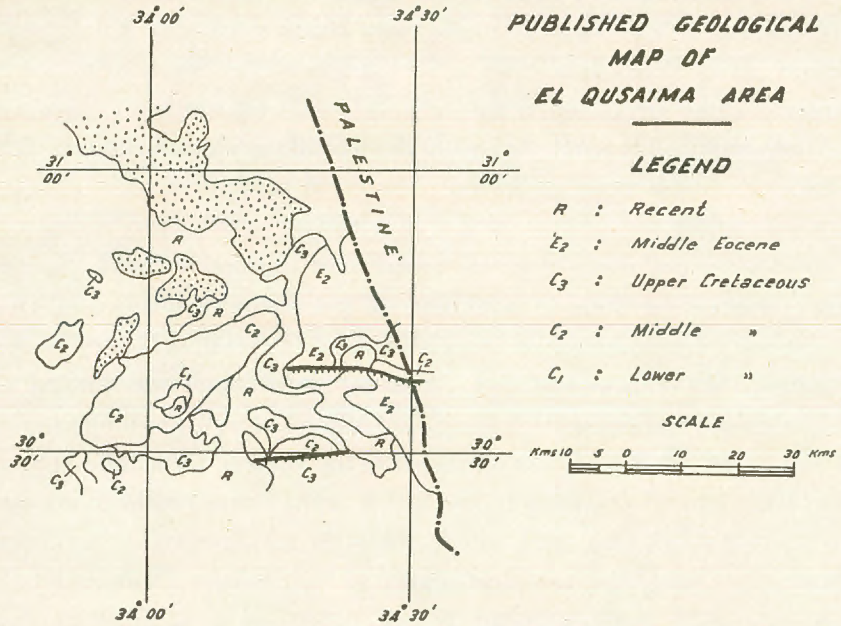

Fig. 1.

3. The central portion of this map is essentially occupied by Cretaceous strata which form the bulk of Gabal El Halal and its foot-hill slopes; no Tertiary strata are indicated either to the south or to the north of Gabal El Halal. The present investigation has shown that the Tertiary strata have a wide distribution in the areas bounding the Cretaceous of Gabal El Halal. In the low synclinal plains to the south and to the north, Lower Eocene and Palaeocene strata are known. In the northern side these are followed on top by other strata belonging to the Middle Eocene and the Upper Eocene. The latter are overlain by yellow marls of Miocene age. On top of the marls beds, Pliocene beach conglomerates and Pliocene deltaic beds are occassionally detected.

4. On this map two sublatitudinal faults are only indicated. The fault pattern is undoubtedly much more complicated than this simple picture. El Halal anticlinal ridge is dissected by at least fourty « Transvers faults». These are mostly oriented in a northwest-southeast direction and are presumably associated with the upfolding phenomenon of this ridge.

In El Qusaima area a regional geophysical exploratory work (mainly gravity-metre) was done by a number of petroleum companies. Of this work some information are only available about the results obtained by the Standard Oil Company of Egypt. A major gravity-high was located at El Khabra and was tested by drilling. El Khabra test well, reaching a depth of 10280 Ft. (3134 m) was bottomed in the Jurassic formations (no oil reported). The discovery in this well of Miocene strata overlying directly the Upper Senonian chalks is rather interesting and becomes a significant factor in studying the palaeogeography of Northeastern Sinai. In El-Qusaima area, a few number of shallow holes was sunk in connection with the search for water but no detailed geological information is available. Most of such holes are located in the present channel of Wadi El Arish, particularily in the area between El Rawafa and El Magdaba (in such holes water is mainly reported in young and old wadi gravels).

GEOMORPHOLOGICAL ASPECTS

El Qusaima area, forming a portion of the folded belt lying to the south and east of the Mediterranean coast, displays a number of morphological features characteristic to folds. These are examplified by elongate anticlinal ridges, elevated structural plateaux and low synclinal plains. The relief of such features is strongly affected by the nature of the constituting rock material.

Gabal El Halal, the most prominent feature in El Qusaima area, is a major anticlinal ridge oriented in a NE-SW direction and rising to more than 700 m above the surrounding plains. It is essentially underlain by weather resistant limestones and dolomites of Cenomanian age.

The low plains (+ 100 to + 200 m), dominated by soft Cretaceous and Palaeogene strata, occupy mainly the synclinal areas on both sides of this ridge. On the eastern side, the low plains rise abruptly into the conspicuous cuestas at El Qusaima (+ 400 to + 600 m) which mark the western edge of the great synclinal plateau (+ 1000 m) between El Halal and Rumman upfolds. The surface of this extensive plateau is dominated by hard siliceous limestones of Middle Eocene age.

Although we have some indication that the main «Sinai Landmass» was raised (regionally) in post-Middle Eocene times, it is apparent that the physiographic feature which we have in El Qusaima area are quite young. These are thought to attain most of their present shape in Plio-Pleistocene times i.e. in connection with the last known phase of strong earth movements (Picard, 1934) which involved both uplift and faulting. The effect of that uplift was strongly felt in «the culminated anticlinal regions of North Sinai». These anticlines became then subjected to strong phases of water abrasion which are mostly responsible for the present hydrographic pattern and for the accummulation of the great quantities of alluvial formations particularily noticeable in the wide foreshore plain of North Sinai. This hydrographic pattern is there developed into a variety of forms but these are almost all characteristic to folded regions. With some exceptions, the drainage lines of El Qusaima area are subordinate to Wadi El Arish master stream (this is mostly responsible for draining Central and North Sinai). In Holocene times, El Qusaima area, as well as the Sinai peninsula in general, was subjected to strong arid conditions which are now felt in the extremely barren surface of the elevated land masses, in the formation of drift sand expanses and dune ridges, and eventually in the presence of the elevated terraces of Wadi El Arish (Shata, 1959).

In El Qusaima area, the following morphologic regions are distinguished (Map 2) :

1. The dissected tableland region.
2. El Halal ridge.
3. Wadi El Arish basin.
4. The dune complex region.

The Dissected Tableland Region :

The « Tableland Region » occupies almost entirely the eastern portion of El Qusaima area. This region, rising in some places to more than + 600 m, continues eastward into the « Central Naqab Upland mass » of South Palestine (+ 1000 m). In our area this « Tableland » descends gradually in a westward and northwestward direction from a maximum height of (+ 600 m) on Gabal El Ain to 260 m on Taret Umm Basis.

On structural basis, the « Tableland Region » of El Qusaima area, occupies a portion of the synclinal area between « Rumman upfold » (+ 1000 m) and « El Halal upfold » (+ 900 m). The surface of this synclinal area is dominated by Middle Eocene strata composed of siliceous limestones. These are underlain by soft layers composed of chalk and marl which are evident in the cuestas occurring close to El Qusaima. The morphology of this synclinal area is characterized by « plateau escarpments » and « table mountains ». The escarpments are quite precipiteous down into the underlying soft chalk and marl, and are covered by dark brown flint and chert. The « table mountains », on the other hand, are either flat topped or has a gently undulating surface with « local rounded caps » (Madra) made of the weather resistant siliceous limestones. The table mountains are cut through by a number of erosional vallies of varying nature and depths (e.g. Wadi El Sabha, W. El Gedeirat, W. Umm Hashim, W. El Abyad, W. El Amr ... etc).

The dissected tableland region of El Qusaima area can be subdivided into three unequal portions :

1. Gabal El Ain (+ 600 m to + 500 m) which is developed into a high tableland mass and is traversed by relatively shallow erosional vallies (erosion has only gone down to the Palaeocene Shales).

2. El Qusaima (+ 440 m) El Muweilih (+ 400 m) Mushraq (+ 440 m) outlier plateaux.

3. Gabal El Amr (+ 430 m) to Umm Basis (+ 260 m) forming a lower tableland mass and showing a number of local elevated points on Gabal El Sabha (+ 450 m), Gabal El Abyad (+ 430 m), and Gabal El Wogeir (+ 320 m).

These different portions bound a wide morphotectonic basin (El Sabha) occurring at least a 100 m below the top of the plateau, as well as some smaller basins (e.g. El Abyad, Umm Hashim ... etc.) which are mainly due to erosion. El Sabha basin is underlain by a broad and gentle upfold, the crestal portion of which is dissected by a number of sublatitudinal faults. The « hydraulic abrosion » and the lithologic nature of the Palaeogene and the Cretaceous sediments are also effective in the formation of this basin. The water has, of course, removed the hard siliceous limestones (Eocene) and exposed the soft chalks and marls (Palaeocene and Cretaceous). In the central portion, there is a local elevated hill (Gabal El Risha, + 350 m) which is almost capped by hard Turonian limestones. The drainage pattern of El Sabha Basin has a typical denderitic form and is connected to a similar drainage pattern belonging to El Abyad Basin through one single channel having its exit between Gabal El Muweilih and Gabal Mushraq. This channel runs in a southwestward direction and collects the drainage of a third, but a rather smaller basin namely El Muweilih, which is also subordinate to the main Wadi El Arish stream. Aside from Wadi El Gedeirat and W. Umm Hashim which drain Gabal El Ain into El Sabha Basin, this « Gabal » is drained by another system (Wadi Qadeis, Wadi Damth Khreiniq and Wadi El Geisi) which joins Wadi El Gaifi. Wadi El Gaifi, a conspicuous subordinate of Wadi El Arish stream, has its intake area located in the « Central Naqab Upland mass ». We learn now that the southern portion of « El Qusaima Tableland » is drained by W. El Gaifi and W. El Muweilih which join Wadi El Arish on the eastern side. As to the western portion of this « Tableland Mass » there is a number of short subsequents which are either connected to Wadi El Hossani synclinal consequent or become lost in the open plains (Umm Shihan, Umm Gataf, Atara) occurring between the tableland and « Makassar El Fanagil Sand sheet ». Wadi El Hossani, running in a southwestward direction, i.e. parallel to Gabal Dhalfaa, joins Wadi El Arish master stream before its enterence into « El Daiqua Gorge ». Eventually, there is the drainage pattern of the northern portion of the « Tableland Region » which dominates Gabal El Amr. This is composed of a number of simple subsequents running in a northward direction and connecting Wadi

El Amr. This Wadi joins Wadi El Azariq in the dune complex area of North Sinai. Wadi El Azariq and Wadi El Haredein, running mainly in an east-west direction, are also subordinate to Wadi El Arish and both join it in the foreshore plain of North Sinai before « Lihfin Gorge».

In the « Tableland Region» of El Qusaima area the Middle Eocene strata constitute the youngest beds exposed on the surface. These rise to about 600 m above the present sea level (eastward at Rumman and southward at Abu Kharuf a 1000 m altitude is attained on the M. Eocene). No Upper Eocene strata are reported in any place in that region. The Upper Eocene strata as well as the Neogene strata are only recognized in few place occurring in the « lowland region» to the north of both the elevated « Tableland» and El Halal Anticlinal ridge. These occur at an altitude not exceeding 150 m above the present sea level. We are, therefore, inclined to believe that in post-Middle Eocene times most of our area (as well as most of the Sinai peninsula; the northern and western foreshore plains are excluded) was raised up and the Upper Eocene regressive sea was only restricted to that lowland region. This situation lasted during the whole Neogene but the features in the «Upland Region» became morphologically developed. The discovery, however, of Miocene marine formations in the Wadi Rakhma in the northern Naqab area of Palestine (lying to the east of El-Qusaima area) at an elevation of + 500 m (Picard, 1953) may point to the rise of the land in that particular locality in post-Miocene times. On the other hand the flat nature of the Neogene strata in our area and their occurrence at such lower altitudes may be suggestive of the lack of strong tectonic disturbances. The rise of the land at Wadi Rakhma might have been balanced with the subsidence in the northern lowland portion of El Qusaima area.

El Halal Ridge.

El Halal Ridge (+ 900 m) traverses El Qusaima area in a NE-SW direction. It has a length of 40 Km, a maximum width of 15 Km and rises to about 700 m above the surrounding plains. It is essentially underlain by the Cenomanian weather resistant limestones and dolomites.

This ridge has an asymmetrical shape and turns more to the southeastern side. When viewed from a distance, El Halal Ridge appears as a smooth elongated conical landmass but when approached, it shows a very complicated internal structure with well developed dip slopes (in almost all directions and at different rates), with the numerous drainage lines which are occassionally developed into deep « erosional canyons » (El Daiqa) and eventually with its crestal portion eroded into an «erosional cirque» (El Hadhira). This ridge, having a «double plunge» system, is dissected by a number of radial and transverse faults of little throw which are thus less noted morphologically. Strong longitudinal faults are not evident, but may be expected in the southeastern side.

El Halal Ridge is a major domal feature belonging to the group of fold structures characterising North Sinai and South Palestine. These are best examplified by Yelleg, El Maghara, Rumman... etc. In these features, there are classical examples of fold morphology which are demonstrated by the developed radial drainage pattern showing characteristic short « ruzes», « cluses» and « gaps» and by the occassional presence of the « crater-like erosional cirques» called « El Hadhira». El Hadhira of El Halal Ridge is roughly circular in shape (dimensions approximately 8 × 5 Km) and shows a clear system of denderitic drainage arteries which join up in a narrow gate-way situated close to the south-eastern flank of that ridge. These are then connected to the synclinal consequent of Wadi El Hadhira which finally ends in the main channel of Wadi El Arish. The surface of « El Hadhira» is occupied by varicoloured « Nubian type» sandstones and clays which are superficially covered by a mantle of limestone boulders and gravels. These are essentially derived from the Cenomanian limestones and dolomites as well as from the Nubian Sandstone series. In the bed of Wadi El Hadhira boulders and gravels are present but it is noted that their sizes decrease gradually towards the junction of Wadi El Arish where they become replaced by calcareous alluvium. On structural basis, « El Hadhira» is situated on the most arched portion of El Halal Ridge. Eastward from it, there is a conspicuous « Hadhira-like» feature where erosion also goes down to the Nubian Sandstone layers. This feature is better referred to as a « ruze», and its formation is associated with a local transverse fault of little throw.

The minor drainage arteries of this « ruze» join Wadi Umm Margab, which is another subordinate to Wadi El Arish. Northward from this « ruze» there is the major canyon-like valley (El Daiqa) where Wadi El Arish cut across El Halal Ridge in a northwest direction. In this particular locality, the « Wadi» changes from a regional « consequent» to a local «antecedent» valley.

The growth of El Halal Ridge was presumably associated with the earth movements which led to the formation of the regional belt of domal structures known in the area south and east of the Mediterranean. Such movements, starting on moderate scale in pre-Cretaceous times, became particularily noticeable at the end of the Turonian. During the whole Tertiary and early Quaternary, similar movements took place intermittently (obviously on the same structural trends) and the resulting features became morphologically developed in Plio-Pleistocene times. With the rise of El Halal landmass, the surface became cleaned of the Tertiary rock units and the uppermost members of the Upper Cretaceous. The summit of El Halal Ridge got carved mostly down to the Cenomanian limestones and dolomites and the flanks worn down to the Turonian chalky limestone beds. With the development of arid conditions, which took place in Holocene times, the soils and plants which might have been present were removed away. The gigantic growth of El Halal Ridge, as well as the main anticlinal ridges of North Sinai, taking place in early Quaternary times, seem to have affected the landscape in most of the inland Sinai areas. These ridges, acting as strong barriers, protected Central and North Central Sinai from the drift sand formations which dominate the northwest corner of the peninsula. However, through the low synclinal plains occurring between the ridges, such formations found important exit places, and became accordingly responsible for the disconnected drift sand patches which we meet occassionally in Central and North Central Sinai.

Wadi El Arish Basin.

Between El Qusaima Tableland and El Halal Anticlinal Ridge, there is a lowland region (+ 200 m) which is occupied by Wadi El Arish main stream and its tributaries. This region, roughly triangular in

shape, constitutes a portion of the wide synclinal area between Rumman and El Halal upfolds. The surface of this area, sloping gently in a northward direction (+ 200 m to + 160 m over a distance of 30 Km), is dominated by soft Upper Cretaceous and Eocene chalks, and by Palaeocene marls. It is dotted by a number of elevated points, which appear as isolated islands. Such points are known at El Ghagham (+ 337 m), at Tini (+ 262 m), Abu El Nigailat (+ 270 m) etc., and their crests are underlain by weather resistant limestones (occassionally flinty) belonging either to the Cenomanian, Turonian, Senonian or Lower Eocene. These elevated points are devoid of any soil cover, but the bounding low areas are mainly covered with recent alluvium and gravels with dominant shiny flint nodules. This recent cover, showing a high calcium carbonate content, is derived from the Cretaceous and Palaeogene strata (essentially limestones and chalks) which are widly distributed in Central and North Sinai. In the vicinity of the main drainage lines, the alluvial formations are developed into terraces which occur at different heights above the present level of Wadi El Arish (Details about the nature of these terraces are not now available). At El Saida (+ 316 m) and Abu El Nigailat (+ 270 m), located in the southern portion of this « Basinal Region», cobble gravels and boulders (subrounded to rounded) are reported at a considerable height (+ 70 m) above the mean elevation of the surface. Their building material consists essentially of limestones and are mostly derived from the Middle Eocene formations occupying the elevated « Tableland Region» and were then deposited on the intensily eroded surface of the Upper Cretaceous limestones and chalks.

This basinal area, owes much of its origin to three fundamental factors which include both the regional and local structural conditions, (edge of a major syncline), the lithological characteristics of the occurring rock units (mostly soft chalks and marls) and eventually to the hydraulic abrasion caused by Wadi El Arish and its tributaries. Between « El-Mitmetni Gorge» and « El Daiqa Gorge», a distance of 35 Km., this « Wadi» is developed into a regional longitudinal consequent stream, running in a north-south direction and forming a broad meandering loop with its convex side directed eastward, and is connected to several conspicuous tributaries. On the eastern side we have Wadi El Sherief,

Wadi El Gurur, Wadi El Gaifi, Wadi El Muweilah and Wadi El Hossani, all of which have their intake areas located in the highlands of east Sinai and El Naqab of South Palestine, Wadi El Metmetni (draining a wide area east of Bir El Hassana), Wadi El Hadhira (draining the crestal portion of El Halal Ridge) and Wadi Umm Margab (also draining portions of El Halal Ridge) join the main channel of Wadi El Arish on the western side. During the rainy seasons (between October and February) occassional floods may take place and the water of this complicated drainage pattern finds its exit into the northern foreshore plain of Sinai through the main « El Daiqa Gorge». Owing to the narrowness of this gorge and owing to the low gradients of the stream (rarely exceeding 2 m/Km) the flood water sometimes accummulates behind that gorge in the form of disconnected and elongate ponds. Along the present channel of Wadi El Arish, the bed rocks are not exposed and are concealed underneath a mantle of alluvial formations which are mainly developed into compact calcareous loam. In a bore hole put down in 1947 at the inlet of « El Daiqa Gorge» 40 m of the alluvial formations were drilled and the bed rock was not reached. This means that in some earlier period, Wadi El Arish has degraded its channel in this particular locality to a depth exceeding 40 m below the surface. The occurrence of this phenomenon close to the axis of El Halal Ridge may point to local up and down oscillatory movements of the surface.

This basinal region is characterized by the occurrence of disconnected cultivated patches (± 200 acres) which depend on local precipitation and on occassional floods. Such cultivated patches are portions of a much wider area (at least 50,000 acres) where the soil and water potentialities are goad and may thus make this area suitable for agricultural expansion.

The Dune Complex Region.

This region occupies the northern foot-hill slopes of « El Halal Ridge» and the « Elevated Tableland Region» as well as a wide portion of the North Sinai foreshore plain. It has morphological characteristics similar to those of « Ghaza Plain» is Palestine. On structural basis, this region

occupies the eastern extremity of the synclinal area lying between Yelleg-El Halal anticlinal axes on one side and El Maghara-Risan Aneiza on the other side. This synclinal area, sloping gently in a northward direction (from + 150 to + 100 m over a distance of 20 Km) is traversed by the master stream of Wadi El Arish. This region and its extension into Palestine, has been described « as a great reservoir» for the modern alluvial and aeolian deposits which mask the Neogene and Palaeogene strata.

Towards the southern portion of this region, there is a belt composed of Upper Cretaceous chalky limestones which are developed into scattered low lying hills with elevations little exceeding + 200 m. Such low hills mark the transition between the upland areas of El Qusaima and the northern plain. In this transitional area there is a regional low northward dip (rarely exceeding 5°). Further down dip, the Cretaceous is overlain by almost flat Palaeogene and Neogene strata. The latter crop out only at Awlad Ali (+ 100 m) and El Magdaba (+ 90 m). In the subsurface, Neogene strata are also reported in El Khabra Well No. 1 (+ 80 m) and are directly underlain by the Upper Cretaceous chalk (which means that El Khabra upfold was truncated before it was then covered with the Neogene sediments-Miocene marls). At Awlad Ali, the Miocene marls are overlain by shallow marine (beach conglomerates) and deltaic Pliocene formations. The latter, resulted from the discharged material of Wadi El Arish into the Pliocene Sea. In Pleistocene times, these were then covered by extensive alluvial deposits which now produce the great piedmont slope declining both gradually and abruptly towards the Mediterranean Coast. This piedmont slope is traversed by Wadi El Arish with its prominent terraces. These terraces, occurring at uniform heights above the present channel of the Wadi, indicate the young morphology of the whole region.

As stated before, the surface of this region is characterized by the occurrence of extensive drift sand formations. Those are developed either into dunes or sheets. These drift sand formations group themselves into four patches :

1. Makassar El Fanagil-El-Khabra (+ 187 m to + 150 m); this is situated in the far northeast portion of this region. The occurring sand

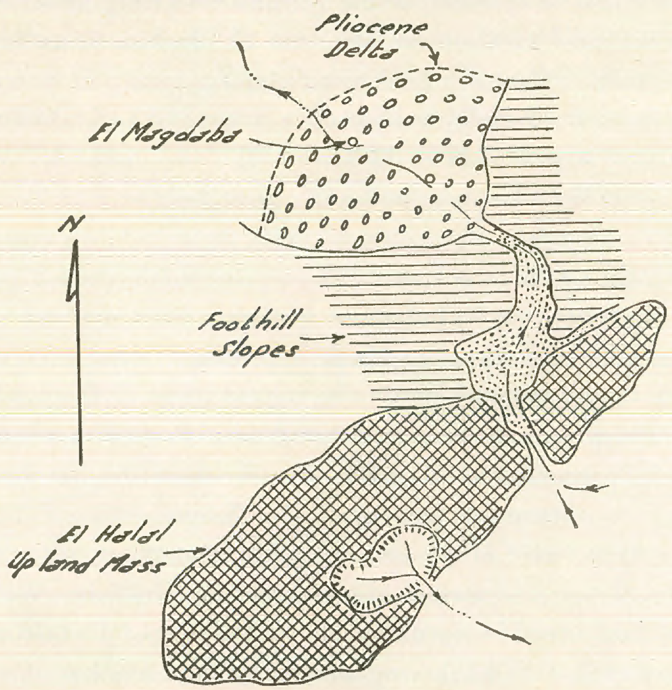

Fig. 2. Pliocene Delta of Wadi El Arish.

formations are mostly developed into relatively high dune ridges (+ 15 m high) which are oriented in a NW-SE direction (lee-ward side facing southwest). Of these dunes, Katib El Teir (+ 135 m) is a good landmark in the foreshore area of North Sinai. Between the dune ridges there are scattered low places (Nagaa, plural Nugue) where limited cultivation of barely and beduin settlements are present. This sand covered patch is traversed by the shallow basins of Wadi El Azariq and Wadi El Haredein, both of which run in an E-W direction and have their intake areas located in El Qusaima Tableland region and El Naqab upland area. Most of the water supply of these two wadis is either conserved in Palestine or lost in the dune area and only limited portions are discharged into the main channel of Wadi El Arish at a point lying a short distance to the south of « Lihfin Gorge ». Between this sand covered patch and El Qusaima upland mass there is an open plain where some cultivation is known and is particularily noticeable at Atara, Umm Gataf and eventually

at Umm Shihan (covering an area of about 5000 acres). In this area layers of dust, sandy clay and sometimes gravels are accumulated as secondary products on the surface. Many of the short subsequents which drain the upland regions are lost in that open plain and contribute annually to the soil and water supplies.

2. El Afeira (+ 213 m); this patch lies immediately north of the northeast portion of El Halal Ridge and bounds the main channel of Wadi El Arish on the western side. The surface of El Afeira is roughly undulating but it lacks the development of many conspicuous dunes. This is underlain by gravel ridges and flinty limestones of Lower Eocene age. Between El Afeira and El Halal Ridge there is another open plain which is traversed by the lateral subsequent of Wadi Abu Yentul. This Wadi, joins Wadi El Arish main stream after its exit from « El Daiqa Gorge ». Aside from this lateral subsequent, there are many short longitudinal consequents which drain part of El Halal upland area and are practically lost in the sand covered area. Within this plain local cultivation exists at Abu Yentul and El Mahayir.

3. El Kafaf (+ 204 m); this covers a wide tract of the northern and western down slopes of Halal Ridge. The sand formations occurring in this particular locality are developed into low undulating dunes and are locally covered with scrub. El Kafaf is dotted by a number of elevated points rising to + 263 m and representing a portion of the Cretaceous uplandmass constituting El Halal Ridge. Many of the transversal subsequents, which drain this mass, are lost in this sand covered region.

4. El Hamza (+ 90 m)-Katib El Sebakh (+ 130 m); these two patches occupy the area to the west of Abu Eweigela and extend to near reaches of Risan Aneiza uplandmass. These are composed of low scattered dunes which overlie an alluvial surface the top layer of which is occupied by dark brown gravels and forming occassional « desert pavement ».

In Addition to El Haredein, El Azariq and El Arish hydrographic basins which traverse the dune complex region, there is another basin occupying its western portion and is known as El Hassana. This basin draining the upland regions situated at Yelleg (+ 1009 m), El Maghara (+ 735 m) and Libni (+ 441 m), has an ill-defined course particularily

in the synclinal plain between El Halal and Risan Aneiza where it is lost in the young sand cover. However, there are some indications which may make us assume that W. El Hassana joins the master stream of Wadi El Arish before its enterence into Lihfin Gorge.

GEOLOGICAL ASPECTS

General Outline :

The surface of El Qusaima area is entirely occupied by rocks of sedimentary origin which belong to the following eras :

1. The Quaternary Era; rocks belonging to this era cover an area approximately 600 sq. Km. (equivalent to 24 % of the total area). These are essentially developed into continental formations which envolve the recent sand dunes, the alluvial deposits of Wadi El Arish, the loess-like deposits of Rafa and the cobble gravels of Abu El Nigailat. Quaternary continental formations other than these are known in the subsurface of the coastal strip between El Arish and Rafaa and are present in the form of calcareous sandstones (old sand dunes). These are locally known as « El Kurkar» and act as the main aquifer in the coastal region, (their age is early Pleistocene). The occurrence of marine Quaternary in El Qusaima area has not been ascertained mainly due to the presence of an extensive blanket composed of continental deposits and to the deficiency of boreholes except of course in the coastal region. However, offshore from El Arish town, the presence of a « Shell-breccia» made of cemented shells of marine mollusca is an indication of the presence of marine Quaternary. Also the « raised beach» known at Abu Sagal to the west of El Arish (Moon and Sadek; 1921 and Shata, 1959), may represent another phase of the marine Quaternary. Eventually some of the « Kurkar Layers» belonging to the Lower Pleistocene, may be partly of marine origin.

2. The Tertiary Fra; strata belonging to this era cover approximately 950 sq. Km. (equivalent to 38 % of the total Area). These are differentiated into two groups; the Palaeogene group (including the Palaeocene

marls, the Lower Eocene flinty chalks and limestones, the Middle Eocene chalks and siliceous limestones and the Upper Eocene gypseous marls and sandy chalks) having a thickness of about 200 m, and the Neogene group (± 50 m exposed and drilled). Members of this last group as well as the underlying Upper Eocene, have limited distribution in El Qusaima area and are only reported from the « Dune Complex» region. Oligocene rocks are not known on the surface of this area (Picard however, mentioned that the « Lower Miocene» strata spoken of by Tromp at Risan Aneiza may belong to the Upper Oligocene. Verbal information from Mr. M. Ghourab of the Anglo-Egyptian Oil fields-Cairo, confirms Picard's assumption). Concerning the Miocene strata, exposures of limited distribution are known at Awlad Ali (marl section). Similar beds are also found in the subsurface at El Khabra. We may expect a wider distribution of the Miocene strata in the subsurface of the foreshore area and we expect also an increase in the thickness of the section basinwards i.e. in the direction of the Mediterranean coast. At Awlad Ali, the Miocene marls are overlain by thin conglomeratic beds which are tentatively assigned to the Pliocene period. These are developed into two phases; a beach conglomerate and a deltaic series. Similar to the Miocene, we expect that the Pliocene beds may extend over a wide area in the foreshore plain of North Sinai.

3. The Secondary Era; this covers about the same area as the Tertiary. Rocks belonging to this era are distinguished into an upper chalk and lime series of Upper Cretaceous age and a lower varicoloured sandstone and shale series of Lower Cretaceous age. This series is mostly found in the crestal portion of El Halal Ridge and has a thickness exceeding 500 m (the lowest beds may in part represent the epicontinental portion of the Upper Jurassic). In El Khabra Well No. 1, the Lower Cretaceous (1000 m thick) is underlain by the Jurassic (an incomplete section; 1400 m thick, was drilled). A similar section is expected below the Lower Cretaceous outcrops of our area.

El Qusaima area is affected by the strong belt of domal structures which characterise the big area south and east of Mediterranean coast. These structures are oriented in a NE-SW direction and are dissected by transvers faults of little throw.

Stratigraphy.

In El Qusaima area, the surface exposures have a thickness of about 1700 m. In the subsurface, the sedimentary succession underlying the lowermost beds (Lower Cretaceous) may have an anticipated thickness of about 2500 m, divided into 1500 m Jurassic, 300 m Triassic and eventually 700 m Palaeozoic. The surface succession can be summerized as follows (Fig. 3) :

TOP	THICKNESS
Pleistocene and Holocene :	
Continental formations; young and old sand dunes, alluvial deposits, loess-like soils....	Variable?
Neogene :	
1. Pliocene beach conglomerates (± 2 m thick) and deltaic formations (± 10 m thick).....	12m ±
2. Miocene marls (marine)..................	15m ±
Palaeogene :	
1. Upper Eocene gypseous shales and chalks...	50m ±
2. Middle Eocene siliceous limestones and chalks	20m to 100m ±
3. Lower Eocene flinty chalk and limestone...	20m to 100m ±
4. Palaeocene gypseous shales and chalky marls.	20m to 50m ±
Upper Cretaceous :	
1. Upper Senonian chalks and marls with occassional brecciated flint....................	40m to 100m ±
2. Lower Senonian chalky marls with flint and shales (missing in some places)...........	0 to 70m ±
3. Turonian limestones (chalky and dolomitic), and shales	100m ±
4. Cenomanian limestones (dolomitic), marls and sandstones	550m
Lower Cretaceous :	
Essentially «Nubian Type» sandstones with intercalations of varicoloured shales and limestones (base not exposed)	520m

COLUMNAR SECTION

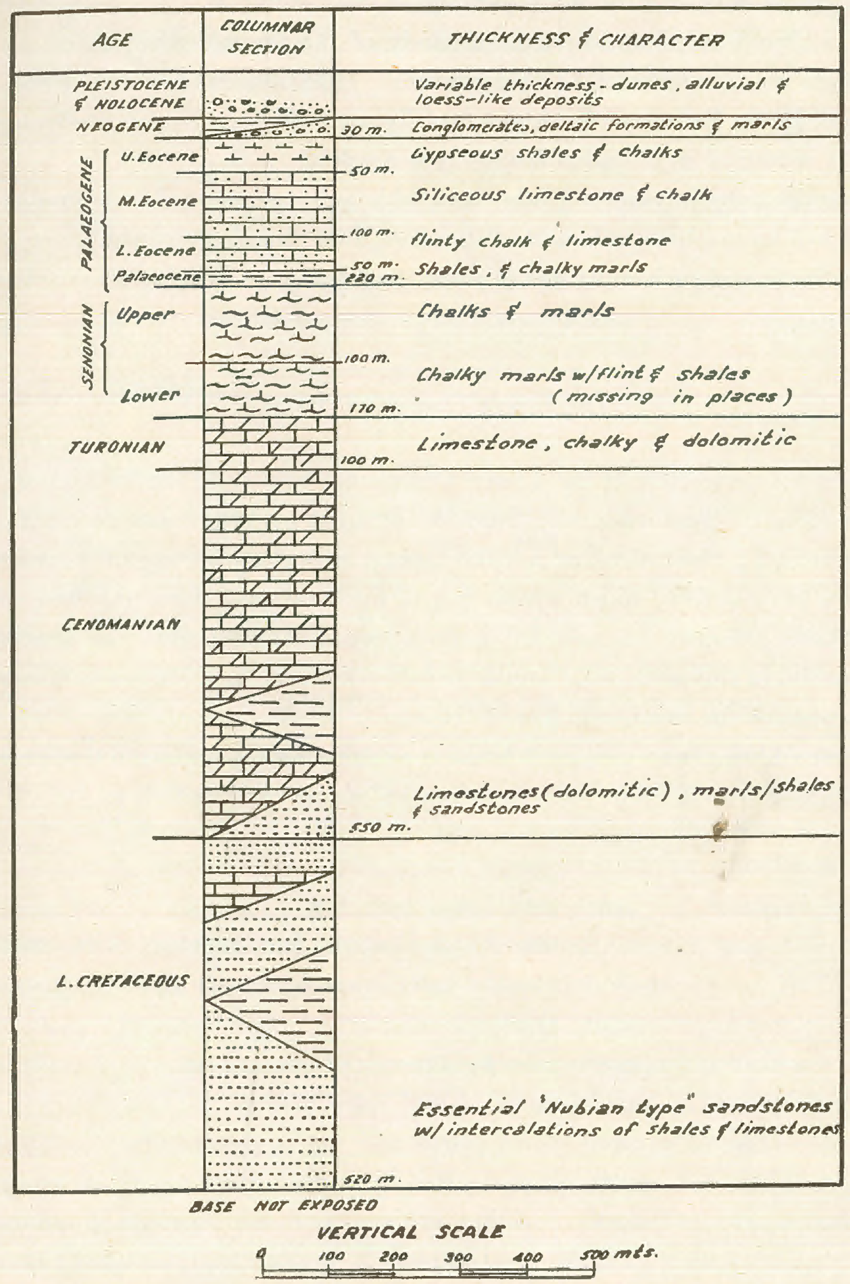

Fig. 3.

Before giving the details about the different stratigraphic units, we might as well refer to the following :

1. No detailed and systematic study of the fauna, either macro or micro was attempted in El Qusaima area. Only local studies were made, both by the Petroleum Geologists and by some of the university students. The results of such studies are not now available.

2. During the mapping processes, although we referred to a number of well known time scale units (Senonian, Turonian, Cenomanian ... etc.) distinction of such units was in most cases based on lithological correlations.

The Lower Cretaceous Strata

Strata belonging to the Lower Cretaceous, constitute the oldest outcrops in El Qusaima area. These are brought up to the surface on the crest of El Halal anticline. These strata, occupying a roughly circular area (45 sq. Km., which equals 2 % of the total area) form the base of a huge erosional cirque « El Hadhira » which characterises the crestal portion of this anticline. Similar beds are exposed in a narrow « Ruze » located to the northeast of « El Hadhira ».

At « El Hadhira » the Lower Cretaceous strata have a measured thickness of about 520 m. The succession can be summerized as follows :

TOP

12 m ...	shale, purple and grey.
70 m ...	multicoloured sandstones, fine grained, with thin bands of sandy shale, sandy limestone and ferruginous oolite.
5 m ...	sandy shale, light grey.
25 m ...	sandstone as above (many stems).
3 m ...	sandy shale, purple.
50 m ...	multicoloured sandstones with thin bands of sandy shale, fossiliferous ironstone and ferruginous oolites (Pelecypods, Gastropods, Ammonites, Corals and Fossil Wood).

35 m ...	shale, grey, with bands of ferruginous oolite.
70 m ...	multicoloured sandstones with thin bands of silty limestone, sandy shale and ironstone.
5 m ...	sandy shale, yellowish brown.
10 m ...	sandy limestone, limy sandstone and silty sandstone, yellow, brown and grey with some fossils.
200 m ...	interbedded sandstone, shale and ironstone (partly covered).
7 m ...	shale, silty, light grey (leaf and stem impression).
30 m ...	sandstone, yellow, with some shale.

Base Not Exposed.

This succession is thus composed of 90 % sandstones and 10 % shales, siltstones and ironstones. The limestone is present in the form of traces only. The sandstones are typical « Nubian Type » facies and may point to an epicontinental shallow water sea. On the other hand the fossiliferous sandy limestones, shales and siltstones indicate relatively deeper marine conditions. Similar successions are known at several localities in North Sinai, namely at El Maghara-Risan Aneiza (about 500 m exposed) at Yelleg (60 m only exposed) at El Giddy (400 m are exposed), at El-Minshera (250 m exposed) at Araif El Naga (200 m exposed) at Kherim (50 m only exposed) ... etc. Of these localities, El Maghara-Aneiza succession as well as that of El Minshera are studied in some detail (Moon and Sadek, 1921 and Farag and Shata, 1954). El Maghara succession is distinguished into an upper relatively deep marine series (Aptian and Albian) and a lower shallow water series (Neocomian). At El-Minshera, the succession is almost developed into undifferentiated « Nubian Type » sandstones. In the subsurface, the Standard Oil Company of Egypt reported about 1000 m of Lower Cretaceous section in El Khabra Well No. 1 (between 2390′ and 5690′). In this well, the Lower Cretaceous succession has a strong lithological similarity to that of El Halal. Only the thickness is apparently overestimated. We expect that the upper portion may belong to the Cenomanian and the lower portion belongs to the Jurassic.

At El Halal, the contact between the Lower Cretaceous and the Cenomanian is tentatively placed between the purple and grey shale bed and a fossiliferous sandy Limestone bed yielding some Gastropods and Pelecypods (mostly broken Oysters). This contact is sharp and is easily traceable in « El Hadhira » erosional cirque as well as in the « Ruze » to the northeast. In these two localities, division of the Lower Cretaceous section into stages on basis of the faunal content, has not been attempted. However, Awad and Fawzi (1956) ascribed some of the occurring fossils to the Albian. Although no information is now available about such Albian fossils, we may think that these compare with the collection which we described in the ferruginous oolite bed (115 m from the top of the section). Concerning the age of the underlying unfossiliferous beds, our knowledge is practically inadequate and unless we have a strong evidence, we shall always think that some of these beds are of Jurassic age (epicontinental series).

In North Sinai, we already mentioned that the Lower Cretaceous section is characterized by the occurrence of marine beds. In this respect, North Sinai differs from Central and South Sinai where the Lower Cretaceous is developed into epicontinental shallow water sandstones. Still, in spite of the occurrence of the marine beds in the Lower Cretaceous of North Sinai, we think that deposition took place almost within the shelf region. The development, however, of more marine facies at El Maghara-Risan Aneiza compared to El Halal may indicate the approach of the northern most portion of Sinai to the center of the sea. Facts from the neighbouring regions indicate that the coastline of the Lower Cretaceous Sea was not straight. The presence, therefore of a local embayment embracing Northern Sinai may be expected.

The Cenomanian Strata

The Cenomanian strata outcropping in El Qusaima area are mostly dominated by weather resistant limestones and dolomites, and are thus responsible for some of the occurring conspiceous upland masses. These strata, occupying an area of about 200 sq. Km. (equaling 8 % of the total area) constitute the main bulk of « El Halal Anticlinal Ridge » and

are also displayed at Tini (a small upfold to the east of El Halal) and at Libni (another small fold to the west). At El Risha, occurring in the central portion of « El Sabha basin », similar beds may be expected.

At El Halal, the Cenomanian succession, having a thickness of about 550 m, can be summerized as follows :

TOP

450 m ...	limestone, white and light grey, medium hard to very hard crystalline and dolomitic, wheathers dark grey and dark brown, with inclusions of ferruginated nodules, many fossiliferous bands present, yielding Ammonites, Echinoids (*Heterodiadima* sp., *Hemiaster* sp.), Rudists, Oysters (*O. Mermeti, O. flabellata*), Pectens (*P.* syriacus), ... etc.
20 m ...	sandstone, light brown and red, no fossils.
60 m ...	limestone, marly, light grey and yellow, fossiliferous.
20 m ...	alternating shale and sandstone, grey, yellow and brown, intercalated with thin limestone bands yielding Gastropods, Pelecypods (Oysters), Worms ... etc.

This succession is thus composed of 90 % limestone, 5 % shale and 5 % sandstone; and yields a number of characteristic Cenomanian macrofossils (no microfaunal studies made).

The Cenomanian succession exists entire only in El Halal anticlinal ridge. In the other sites (Tini and Libni) only the uppermost beds are present. Concerning the lowermost beds of this succession, these have a wide distribution in « El Hadhira erosional cirque » and overlie directly the Lower Cretaceous (no apparent stratigraphic break). Similar beds are also known at the local « Ruze » to the northeast of « El Hadhira ». In « El Hadhira », the lowermost beds of the Cenomanian are followed upward by the rest of the succession to form the bulk of « El Halal Anticlinal Ridge » in a series of majestic dip slopes which tend to be vertical in the southeast portion. These slopes, rising in some places to about 700 m above the floor of the surrounding plains are dissected by a conspicuous radial drainage pattern which terminates either in

Wadi El Arish basin or in the undrained alluvial plains to the north. Many of the drainage lines are canyon-like and are thus hard to traverse from one side to the other. Of these « Canyons», the transversal one separating the main body of Gabal El Halal from Gabal Dalfaa is most conspicuous. This « canyon» is locally known as « El Daiqa» and is caused by Wadi El Arish itself where it cut athwart the main anticlinal ridge (Shata 1959). The outer flanks of the Cenomanian upland mass are followed by low-lying and less tilted dip slopes composed of Turonian strata. On lithological basis, these are quite similar to the Cenomanian strata. In El Halal district, as well as in many other places in North Sinai the contact between the Cenomanian and the Turonian is hard to determine. This contact is tentatively placed on top of the « Ammonite Bed» (Moon and Sadek, 1921, and Farag and Shata, 1954). This bed is an excellent marker and was followed for almost 90 Km around El Halal Ridge. In many places around that ridge, this bed affords wonderful examples of cross sections in the casts of the occurring Ammonites, which are good material for study.

Outside El Qusaima area, Cenomanian strata are known at El Maghara (about 500 m) at Yelleg (about 340 m) at Araif El Naga (about 250 m)... etc. In the subsurface, Cenomanian strata are reported in El Khabra Well No. 1 and have a thickness of 326 m (may be underestimated). In the wells drilled in Central Sinai (Nekhl, Abu Hamth and Darag) the Cenomanian strata have a thickness of 320 m. In an isopach map prepared by the writer (Shata, 1957), it is noted that the Cenomanian succession shows an increase of thickness in the northward direction (Maximum presumed thickness, equaling 800 m, is attained along the coast. The assignment, therefore by Said and Barakat of 1100 m to the Cenomanian section of Gebel Asagil in El Maghara Area is overestimated). Again the presence of local elongate troughs has also been pointed out by the writer and by Bandali, 1959. Of all the Cenomanian occurrences above mentioned, attempts to divide the succession into upper and lower portions on basis of the fauna, were made only in El Minshera, lying close to Yelleg (Awad and Fawzi, 1956). The thickness of the Cenomanian section as described by them is underestimated (125 m only). Said and Barakat described planktonic

microfossils belonging to the Lower Cenomanian at Gabal Asagil in El Maghara area.

In El Qusaima area and also in almost the northern third of the Sinai peninsula, the Cenomanian succession as well as the Turonian has similar lithological and biostratigraphical characteristics including enrichment of the limy and dolomitic facies, presence of marls and shales, slight development of sandstones and occassional abundance of Oyeters and Ammonites. These characteristics point to relatively deep marine conditions (presumably not vary far from the sub-littoral region of the sea). During sedimentation, local oscillations took place and were probably connected to mild epeirogenetic movements. Reviewing the literature on the Palaeogeography of the Upper Cretaceous of Sinai and of the neighbouring regions which is mainly included in the work of Moon and Sadek (1921), Picard (1943), and Farag and Shata (1954) we are told of a regional continental period (locally with volcanism and faulting) comprising the interval between the Jurassic and the Lower Cretaceous. This interval resulted from epeirogenetic vertical movements (no orogenesis are detected and in this respect we may disagree with Bandali). During the later half of the Lower Cretaceous (Aptian-Albian) the land sank gradually and a transgression took place. This process continued during the Albian-Cenomanian and also during the Turonian where the sea covered almost all Sinai. At the time when the Southern two thirds of Sinai were close to the shore of that sea (Tethys), the Northern third was situated close to its deep portion.

The Turonian Strata

In El Qusaima area, Turonian strata are known in the following localities :

1. The outer slopes of El Halal Anticlinal Ridge; the Turonian strata are developed into an almost continuous band of varying width bounding the elevated Cenomanian landmass.
2. The outer slopes of Tini anticlinal ridge.
3. The crestal portion of El Risha faulted anticline.
4. The crestal portion of El Ghagham faulted monocline.

The last three sites are placed within the major synclinal area between Rumman upfold and El Halal upfold. The total area occupied by the Turonian strata approximates 100 sq. Km. (equaling 4 % of the total area). The succession, having a thickness of about 100 m, can be summerized as follows :

TOP

80 m ...	limestone, chalky white, weathers grey, fossiliferous (Pelecypods, Rudists and Gastropods).
1 m ...	shale, grey and green.
0.5 m ...	limestone, chalky white as above, fossiliferous (*Echinobrissus* sp., *Hemiaster* sp.).
9 m ...	shale, grey and green.
0.5 m ...	limestone, yellowish brown, hard crystalline, fossiliferous (*Hemiaster* sp., *Nerinea* sp. and other Gastropods, *Ostrea* sp., *Plicatula* sp. and other Pelecypods).
9.0 m ...	shale, grey and green.

The Turonian is thus dominated by lime facies and is lithologically similar to the topmost portion of the Cenomanian. Local dolomitization of the limestone beds and also the presence of thin flint bands is another characteristic feature of the Turonian succession.

Outside El Qusaima area, Turonian strata are reported in many places of North Sinai, namely at El Maghara area (200 m), at Yelleg area (140 m), at Kherim area (200 m) at Araif El Naga area (130 m)...etc. Similar strata are also reported in a number of wells, namely El Khabra Well No. 1 (Turonian and Lower Senonian strata are not differentiated and have a thickness of 170 m only), and in Nekhl and Abu Hamth Wells where 250 m are drilled. Attempts to draw an isopach map of the Turonian strata in Sinai were made (Shata, 1957 and Bandali, 1959). In North Central Sinai, we have the greatest reported thickness of the Turonian succession (250 m). Southward from this region, this succession shows a gradual decrease of thickness (the Turonian shoreline passing somewhere through the southernmost portion of Sinai). In the northern portion of the peninsula, although this succession, tends to

thicken in the northward direction, the picture is rather complicated. This is obviously due to a mild orogenic phase which resulted in the development of isolated land masses of low relief separated by shallow depressions. This phenomenon caused, not only a considerable variation of the thicknesses of the Turonian succession in North Sinai but also affected the facies. Also, such movement was responsible for the discordances noted between the Turonian and the Senonian formations. For example, around El-Halal major upfold, as well as around Tini and Libni smaller upfolds the Turonian is directly overlain by the Upper Senonian Chalks (no direct evidence for the occurrence of the Lower Senonian strata is available) Such discordances are sometimes marked by the presence of basal conglomerates e.g. at Yelleg (Moon and Sadek, 1921). On the other hand, around El Risha faulted anticline and El Ghagham faulted monocline, which are located on the edge of the major synclinal area between El Halal and Rumman Upfolds, the Turonian strata pass into those of the Lower Senonian without any apparent discordance. We may accordingly think that the nonexistance of the Lower Senonian around the main upfolded areas in North Sinai is an indication that such areas were morphotectonically developed in post-Turonian times.

THE SENONIAN STRATA

In El Qusaima area, the Senonian strata have a very wide distribution, occupy almost the lowland regions, and cover an area of about 400 sq. Km. (equivalent to 15 % of the total area). These strata are developed into a lower series composed of marly limestones and flint chalks (Lower Senonian) and an upper series dominated by massive chalk (Upper Senonian). As stated above, strata belonging to the Lower Senonian are sometimes missing and in this case the Upper Senonian chalks overlie directly the Turonian.

Within our area the Senonian succession exists entire only at El-Ghagham El Risha (occurring within the great synclinal area), and eventually at El Abeiriq (occurring in the synclinal area between El Halal and Yelleg upfolds). In these localities the Lower Senonian formations contribute to the topography and form local isolated hills which are

partly or totally covered with shiny flints. On the other hand, the areas occupied by the Upper Senonian Chalks (dominating El Sabha Basin, Wadi El Arish Basin and the southern portion of the Dune Complex Region) are almost featureless and are badly covered with talus deposits, wadi alluvium, occassional drift sand formations (El Kafaf) and sandy soils (Umm Shilan and Abu Yentul).

At El Ghagham, the Senonian succession, having a thickness of about 200 m, is summerized as follows :

TOP

130 m ... chalk, snow white, massive to poorly bedded, weathers soft chalky or grey shaley, lowest portion yielding *Ostrea vesicularis,* Lamk. and sponges (*Ventriculites*, sp.) preserved in limonite; characteristic microfossils are also present.

70 m ... limestone, yellow, grey and brown, marly, hard to medium, weathers medium hard to soft, top portion containing flint nodules, weathering shiny, many rich fossil bands present (yielding *Hemiaster Fourneli,* Desh; *Holaster,* sp., *Ostrea dicotoma,* Bayl; *O. Costei,* Cog.; *Pecten* sp.; *Arca* sp.; *Anatina* sp.; *Trigonia* sp.; *Plicatula* sp. and Gastropods).

The succession is thus dominated by chalk and lime facies, with varying amounts of marls. At El Risha, located close to the Palestine border, this succession shows an enrichment of flint which is present in a brecciated form.

Outside El Qusaima area, Senonian strata are known from several localities namely, El Maghara (Upper Senonian strata only exposed and have a thickness of 45 m), Yelleg (300 m), Kherim (200 m), Araif El Naga area (Upper Senonian either reduced to 6 m of sandstones or 130 m of chalk; Lower Senonian has a thickness of about 60 m). At El Hamra and Wadi Sudr in West Sinai and also at El Themed in East Sinai the thickest Senonian sections are exposed (300 m Upper

Senonian and 100 m Lower Senonian). In the subsurface, Senonian strata are also reported (at least 250 m in El Khabra Well No. 1 and about 230 m in Nekhl-Abu Hamth Wells).

The study of the isopach maps prepared by the writer and by Bandali indicates that the Senonian has followed approximately the same palaeogeographic pattern as that of the Turonian, but still we must admit that the detailed configuration is not fully understood. During the Senonian, we expect that most of the folded regions in North Sinai were further developed morphologically. In the Lower Senonian some of the upfolds were not submerged and remained as islands (El Maghara, El Halal). On the other hand, during the Upper Senonian the area was all covered by the sea but the depths were not uniform.

The Palaeocene Strata

In El Qusaima area, the transition of the Senonian into the Eocene is marked by the presence of a grey shale bed of varying thickness. This bed is well preserved in the « Cuestas» of the « Eastern Dissected Tableland Region» and is there covered with dark brown flints (mainly derived from the overlying Eocene strata). This shale bed is also detected in the shallow synclinal area lying to the south and east of El Halal Ridge. In this synclinal area, this bed underlies a thin mantle of Lower Eocene flinty limestones or is covered by talus deposits. In this particular area the shale bed is dissected by innumerable subsequent wadis which drain the eastern portion of El Halal upland mass and thus give rise to a wonderful gully erosion pattern. Again, the crestal portion of Taret Umm Basis Dome, developed into a shallow erosional cirque, is underlain by soft Palaeocene shales. Eventually, in the foothill plains to the north and west of El Halal ridge, disconnected exposures of this shale bed are known at Umm Gataf, El Mahayir, El Abraqien ... etc. In this portion of El Qusaima area we may think that the Palaeocene shales form a narrow and elongate band bordering the Cretaceous.

In the vicinity of El Qusaima settlement, the grey shale section has a measured thickness of about 50 m. This is underlain by the Upper Senonian chalks (no apparent discordance recorded) and are overlain by the

Eocene flint chalks and limestones (also without any observed unconformity). Outside El Qusaima area shale sections, having the same chronological position, are known from many places in North Sinai but the thickness is not uniform e.g. at El Maghara (1 m ±), El Minshera (65 m), Araif El Naga (50 m), Nekhl-Abu Hamth (45 m) ... etc. Discussion of the age of such shale sections was made by several workers on basis of their microfaunal content but the subject is still controversal. However, the general attitude is to consider these shales as « passage-beds » between the Cretaceous and the Eocene strata (Henson, 1938, Nakkady, 1949 and Farag and Shata, 1954).

The Eocene Strata

Eocene strata constitute about 1/3 of the surface exposures in El-Qusaima area and occur in the form of three main disconnected patches. One of these patches comprises almost entirely the « Eastern Dissected Tableland Region ». In this region both the Middle Eocene and Lower Eocene strata are represented. Eocene strata are also found in the shallow synclinal area to the south and east of El Halal upfold. In this synclinal area only the Lower Eocene strata are preserved and form a wide « Hamada » plain which is mainly covered with brown flints. On the other side of El Halal upfold Eocene exposures are known along the course of Wadi El Arish between El Rawafa and Awlad Ali, and are also Known at El Afeira, El Gharaqda, El Kafaf and in the vicinity of Libni upfold. On this side of El Halal, Lower Eocene flinty limestones and chalks are detected (El Rawafa, Umm Gataf, El Afeira and El Abraqein) and are expected to form an almost continuous band running from Taret Umm Basis to Libni where it then swings southward to form a portion of the synclinal plain between El Halal and Yelleg. Northward from El Rawafa, the Lower Eocene strata are overlain (without any apparent discordance or angular unconformity) by chalk and siliceous limestone beds yielding big Nummulites and other micro fossils the age of which has been designated as Middle Eocene. Similar beds crop out at El-Gharaqda on the Ismailia-El Arish road close to Abu Ewigela and at El Abraqein. The Middle Eocene strata form presumably another continuous band parallel to the Lower Eocene. Between El Halal and Yelleg, the synclinal plain is occupied by similar Middle Eocene strata which are occassionally covered with drift sand and scrub. In few localities (Awlad Ali and El Kafaf) the Middle Eocene strata are overlain by gypseous clays and chalks, yielding a rich microfaunal content of *Hantkenia* sp., *Gumbelina* sp. ... etc. which are assigned to the Upper Eocene. The Upper Eocene strata are thought to have a wider distribution under neath the young Neogene and Quaternary deposits which dominate the synclinal plain between El Halal and Risan Aneiza. In El Khabra Well No. 1, no Eocene strata are detected as the Miocene marls overlie directly the Upper Senonian Chalks. This may not mean that similar beds are present away from the crestal portion of El Khabra upfold. Eastward from this site Picard (1943) referred to the occurrence of Upper Eocene strata in the vicinity of Bir Sheba. In El Qusaima area the restricted occurrence of the Upper Eocene strata to the northern lowland region (altitude rarely exceeding + 150 m) and the absence of any relics on the Middle Eocene strata which constitute the elevated « Tableland » region (600 m) make us believe that in Upper Eocene times the regressive sea covered only that low portion of North Sinai. From North Sinai, the Upper Eocene shoreline swings in a southward direction to embrace the western foreshore plains.

In El Qusaima area, measurement of the Eocene succession was not made in a detailed way. However, in the vicinity of El Qusaima settlement, the thickness of the Lower Eocene was estimated as 30 m (succession made of chalk and chalky limestone with flint). In the northern synclinal area the thickness of the Lower Eocene increases to about 50 m (El-Rawafa). This is compared to 100 m in North Central Sinai (Nekhl area) and to about 200 m in South Central Sinai (Gabal Geneina and Gabal Rigim). In some places in North Sinai, the Lower Eocene strata are either missing (North western flanks of Araif El Naga upfold, Ras El-Gindi ... etc.) or reduced to few metres (El Maghara, Umm Khesheib, El Raha ... etc.). About the Middle Eocene strata, the succession, having a thickness of about 100 m (cliffs of Gabal El Ain in the vicinity of Ein El Gedeirat), is composed of massive crystalline limestone with concretionary flint and abundant *Nummulite* sp., chalks and chalky

limestones yielding abundant *Ostrea multicostata.* To the north of El-Rawafa, the thickness of the Middle Eocene succession rarely exceeds 50 m. Outside El Qusaima area similar successions are known at Umm Khesheib, El Raha and also in the great synclinal plain between Yelleg and El-Maghara upfolds (at the mouth of Wadi El Mushabbi, the SOE[1] geologists described 345 m of Middle Eocene strata which are strongly titled in southeast direction). Concerning the thickness of the Upper Eocene strata our Knowledge is practically inadequate. This can, however, be roughly estimated as 30 m. Outside El Qusaima area, Upper Eocene strata are reported from West Sinai (Ball, 1916, El Ansari, 1955, Farag and Shata, 1956). In this portion of Sinai, the succession, having a thickness exceeding 400 m is developed into a lower chalky series and an upper series composed of sandstones and clastic limestones of shallow water origin. This upper series, indicating the approach to a continental or shallow water phase at the end of the Eocene, is not known in our area and is perhaps concealed underneath the Neogene and Quaternary.

About the discordances which we have in Sinai, either between the Cretaceous and the Eocene or within the Eocene itself there is some divergence of opinion. Picard (1943) has the idea that these are « epeirogenic discordances» but Shukri (1954) referred to « pulses of orogeny» as the causal mechanism of such « unconformities». Broadly speaking Sigaiv (1959) attributed the relative small thicknesses of the Eocene strata in Sinai to « typical monoclinal conditions», and regarded the facies as a regressive type resulting from the « regional uplifts at the end of the sedimentation cycle». Application of this general conception to our area may not lead to any rigid conclusions. However, we feel that we may be justified if we assume that in Middle Eocene times most of the Sinai area has been lifted up and by Upper Eocene times the sea retreated to occupy portions of the northern and western foreshore plains. This pattern lasted almost during the whole Neogene and became developed in Plio-Pleistocene times when the landforms of the Sinai peninsula attained most of their present shape.

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[1] S O E = The Standard Oil Company of Egypt.

The Neogene Strata

In El Qusaima area, Neogene strata have a very limited distribution and are known from one locality along the course of Wadi El Arish in the vicinity of Awlad Ali (+ 109 m). The succession, having a thickness of about 15 m is composed of yellow marls (Sakia Marls) which yield a rich microfaunal content (according to Mr. M. Ghourab the Chief Palaeontologist of the A E O[1] and to the geologists of the S O E this content has Miocene affinities). At Awlad Ali the marls are overlain by a reddish conglomerate bed (2 m ± thick) which forms a conspicuous weather resistant cap. This conglomerate bed, rising about 15 m above the floor of Wadi El Arish, dip regionally in a northward direction at the rate of 4 m/km and appear in floor of the « Wadi» at El Maghdaba (+ 80 m). This same bed is expected to have a wide distribution in the foreshore plain of North Sinai where it forms the base on which were deposited the Quaternary sediments. In the vicinity of El Arish town on the Mediterranean coast, this conglomerate bed is anticipated at a depth of about 130 m below the surface. This bed yields a variety of poorly preserved fossils (some of which are reworked) and may represent a Pliocene beach formation. Pliocene deltaic deposits (alternating, gravels, gypseous clays and sandstones) are also known at Awlad Ali and extend to El Magdaba (Shata, 1959). These deposits represent the discharge material of Wadi El Arish into the Pliocene sea (Fig. 2). In the subsurface, beds similar to the « yellow marls» are reported in El Khabra Well No. 1. These, having a thickness of 42 m (drilled between 60 m and 102 m from the surface) overlie directly the Upper Senonian. On top, the marls are overlain by modern Quaternary deposits (mostly alluvial and aeolian formations).

Aside from these two occurrences no Neogene strata are reported in El Qusaima area. At Risan Aneiza, located to the north of this area, Neogene deposits of uncertain age are known (Tromp, 1941 and Picard, 1943). Verbal information from Mr. M. Ghourab, points to the possibility

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[1] A E O = Anglo-Egyptian Oil fields.

that such deposits can be correlated with those of Awlad Ali and El Khabra. The palaeogeographic sketches made by Picard, 1943 and by the writer, 1954 reveal a much wider distribution of the Neogene strata in the foreshore area of North Sinai. These are mostly masked underneath the Quaternary deposits. In our area, although no Oligocene strata are detected (this period may be represented by an erosional phase) marine strata are expected in the subsurface particularily close to the coastal strip. Facts from the wider Eastern Mediterranean region indicate that along the North Sinai coastal strip, the marine Oligocene may attain a considerable thickness.

The Quaternary Strata

In El Qusaima area, the Quaternary strata are distinguished into two main phases; an alluvial phase and an aeolian phase. These two phases are widely distributed in the synclinal plain to the north of El-Halal Ridge and then extend northward to the Mediterranean coast. In the lowland region to the south and east of that ridge (dominated by Wadi El Arish Basin) the Quaternary is mostly in the form of alluvial deposits. These are either composed of calcareous loam (in some places suitable for cultivation) or of dark brown gravels occurring in the form of ridges rising few metres above the present channel of the « Wadi». Of special interest among this gravelly phase, are the « cobble gravels», known at El Saida-Abu El Nigailat (+ 270 m) which rise more than 50 m above the Wadi. These gravels (subrounded to rounded), having a thickness of about 2 m, are remnants of a much wider gravel series which has certainely covered the lowland region between El Halal and the « Elevated Tableland» at an earlier stage before Wadi El Arish has lowered down its channel to the present form. Quaternary deposits are also known in « El Hadhira» erosional cirque where they are mostly developed into boulders (angular to subangular) representing the downwash material of the surrounding Lower Cretaceous and Cenomanian strata. In the synclinal plain to the north of « El Halal Ridge», the alluvial deposits are also dominated by Wadi El Arish Basin and are distinguished into three conspicuous terraces occurring at uniform height above the present

channel of the « Wadi». These terraces rising 10 m, 22 m and 35 m respectively above the present channel, were followed from the vicinity of El Rawafa to El Arish town on the Mediterranean, i.e. over a distance of 50 Km (Shata, 1959). Overlying the alluvial deposits, drift sand accumulations are present and are either developed into undulating sand sheets or into scattered dunes (El Khabra + 150 m, Umm Kheizina + 150 m, Makassar el Fanagil + 187 m, El Afeira + 211 m, Katib el Sabakh + 130 m, El Kafaf + 220 m and El Hamza + 90 m). Within such localities, both prominant and travelling dunes are known. The first type has a somewhat hardened surface and always appear as low undulations covered locally with scrub. An older phase of this type of dunes is known on the « Upper Level» of Wadi El Arish (Shata, 1959). The travelling dunes form local elongate ridges (e.g. Katib El Teir) stretching in a W. NW-E. SE direction and are developed into a variety of forms (no detailed study made). The question of the origin of the sand accumulations in North and West Sinai has not been answered in a satisfactory way. Moon and Sadek (1921) suggested that the sands are derived from « an ancient sea bottom which has been raised in recent geological times» or from « a sandstone strata of Upper Miocene age». Shukri and Phillip (1959) are of the opinion that the « Nile Sediments» contribute to the formation of such sand deposits.

In the North Sinai Mediterranean littoral region, lying to the North of El Qusaima area, we are informed of some marine phases belonging to the Quaternary. These include; 1) a shell-breccia which is now collected from the offshore region at El Arish and is used as a building stone; 2) the pre-Romman raised beach at Abu Sagal (+ 12 m) to the west of the mouth of Wadi El Arish (Shata, 1959); and 3) one or more phase of the « Kurkar» formations (Lower Pleistocene) which are reported in the subsurface of El Arish district. In addition to these marine phases of the Quaternary, the writer referred to the successive stages in the retreat of the Mediterranean coastline which took place in Sicilian times (+ 82 m), Melazzian times (+ 55-60 m), Tyrrhenian times (+ 33-35 m), Monasterian times (+ 22 m) and pre-Romman (+ 12 m) until it attained its present form. This may mean the presence of more marine phases of the Quaternary period, but these are now

concealed underneath the modern terrestrial deposits. Their nature and distribution is thus not known to us. This can only be understood from the study of bore samples.

Geologic Structure :

El Qusaima area, constituting a portion of the « mobile belt» of the Southern Mediterranean region, is affected by strong folds which are oriented in a NE-SW direction. Of the occurring folds, El Halal is a major anticlinal feature mostly underlain by weather resistant Cenomanian limestones and dolomites and thus forms a prominant topographical feature rising 700 m above the surrounding plains. The crestal portion of this anticline is a major « Hadhira Type» depression which is eroded down to the base of the Lower Cretaceous. An analysis of the geological structure of this anticline is made in brief, by the writer (Shata, 1956) and the reader can refer to our notes on this subject. To these notes, we might as well add that the axial length of this anticlinal feature can be extended in the northeast direction, i.e. towards Taret Umm Basis, and thus totals about 60 Km. Folding irregularities are noted along this axis and form a series of local structural « highs» and « lows ». The former are displayed at Taret Umm Basis, Dalfaa, El Hadhira (apex) and also close to its southwestern tail.

To the south and east of El Halal anticlinal axis, there is a major syncline which separates it from Rumman anticline in South Palestine. The surface of this synclinal area is dominated by Eocene strata and its structural configuration is complicated by a number of subsidiary anticlines and monoclines of low relief (Tini + 262 m, Abu El Nigailat, El Ghagham + 337 m and El Risha + 483 m). These subsidiary features are all eroded down to the Upper Cretaceous and are dissected by normal faults of low displacement. Between Abu El Nigailat—El Ghagham faulted monocline and the southeastern steep limb of El Halal anticline, there is a shallow asymmetrical syncline in which are still preserved relics of Lower Eocene flinty limestones. This syncline is oriented in a NE-SW direction, i.e. parallel to El Halal Axis.

Between El Halal anticlinal axis and El Maghara-Risan Aneiza axis there is a major synclinal depression oriented also in a NE-SW direction.

This syncline is filled with a variety of Palaeogene, Neogene and Quaternary sediments. Within this synclinal area, small anticlines of low structural amplitude are known at Libni + 440 (surface anticline exposing the top layers of the Cenomanian) and at El Khabra + 70 m (gravity-high ; presumably an eroded anticline of lower topographical and structural relief compared to Libni). Between El Halal and Libni, a sharp syncline exists and its top portion is occupied by Middle Eocene strata. Another sharp syncline is also expected between Umm Basis (Northeastern terminus of El Halal axis) and El Khabra but this may be associated with faulting.

About the evolution of the structural forms which we have in El-Qusaima area and in almost all North and Central Sinai the reader can also refer to our notes on the « Structural Development of the Sinai Peninsula». It is almost acceptable that the present morphological pattern of the occurring structural forms is quite young (Plio-Pleistocene).

Further more, during the discussion of the stratigraphy of El Qusaima area, we drew the attention to the following facts :

1. The occurrence of Upper Eocene strata only in the low synclinal plain to the north of El Halal Ridge (elevation rarely exceeding 150 m above the present sea level).

2. The occurrence of Neogene strata only in the same area at lower altitudes (rarely exceeding 100 m above the present sea level).

These two occurrences make us conclude that since Upper Eocene times most of the North Sinai area was raised up into a continental landmass (present morphological pattern not established yet) and the « regressive sea» occupied only portions of the lowland region to the north of El Halal and Risan Aneiza. The reference by Picard (1951) to the extention of the Miocene coastline in Palestine up to the « region of the present Upland» (e.g. Wadi Rakhma 25 km to the southeast of Beer Sheba, which occures at a height of + 500 m) or even « up to the watershed» (e.g. Kurnub + 500 m ±), where the « folds were truncated and covered with a thin Miocene layer» may not conflict with our conclusion. We may think that deposition of the Neogene strata in these localities took place under about the same enviromental condition as that of North Sinai, but the high altitudes attained by the Neogene strata in Palestine point to a local rise of the land in post-Miocene times (North Sinai

remained almost within the foreshore region). The occurrence of truncated folds covered with thin Miocene layers is witnessed in the low plains of North and West Sinai (El Khabra + 70 m and Ayoun Musa at about sea level) as well as in the Bitter Lakes region (Abu Sultan + 58 m). Unlike the upfolds of North Sinai, which occupy portions of the Sinai upland region where no Neogene is reported, these folds remained always within the Sinai lowland regions.

SOIL AND WATER POTENTIALITIES

El Qusaima area (2500 sq. Km. or 600.000 acres) is occupied by sedimentary rocks which are either consolidated or nonconsolidated. For the most part, the nonconsolidated products (occupying an area of about 200.000 acres) form a superficial layer, the thickness of which ranges from few centimeters to many metres and lie on the original rock material. These are distinguished into three main classes :

1. The alluvial deposits of Wadi El Arish and its tributaries. These are mainly composed of « calcareous loam» occassionally intermixed with varying amounts of pebbles, cobbles, boulders, and drift sand.

2. The weathered products of the « Upper Senonian chalks» and « Palaeocene shales» which remained in situe; mainly witnessed in « Wadi El Arish basin», in « El Sabha basin», in « El Abyad basin» and in « Umm Hashim—El Gedeirat basin».

3. The aeolian deposits which have a wide distribution in the synclinal plain to the north and west of « El Halal Ridge».

Over such nonconsolidated deposits, a limited cultivation (mainly barely) is scattered, and depends almost on local precipitation and on occasional floods.

Referring to our morphological subdivisions of El Qusaima area (Map 2), the main accurrences of cultivated patches are as follows :

1. In the eastern dissected tableland region the following occurrences are known :

a) El Sabha — El Abyad basins.
b) Wadi El Gedeirat where we have a permanent supply of water.

c) Wadi Qadeis where we have another permanent supply of water.
d) Many of the Wadis dissecting Gabal El Ain (e.g. W. Umm Hashim).

2. In Wadi El Arish Basin these occurrences are known :

a) Abu El Nigailat — El Saida.
b) Portions of Wadi El Gaifi.
c) Portions of Wadi El Muweilah.
d) Portions of Wadi El Harab close to the inlet of El Daiqua Gorge.
e) Many places in Wadi El Hossani.
f) Many places in Wadi El Mitmetni to the south of « El Halal Ridge».

3. In the dune complex region the following occurrences are known :

a) The open plain between El Rawafa and Taret Umm Basis with special reference to Umm Shihan, Umm Gataf, Atara and eventually Ruweisat.
b) Abu Yentul.
c) Many places along the course of Wadi El Arish between El Rawafa and El Magdaba.
d) Few places in the open plain to the east of Awlad Ali.

4. In El Halal Ridge little occurrences are known and are mainly localized in « El Daiqua Gorge » and in few other transverse wadis.

The area of the occurrences above mentioned, does not exceed 500 acres which equals 0,25 % of the total area covered by the nonconsolidated deposits. Taking into consideration the morphology of such deposits and the microrelief of the sites where they are found, we are justified in assuming that 50 % of this big area (about 100.000 acres) may have reasonable soil potentialities and can, therefore, support a much wider cultivation scheme (Fig. 4).

Like almost all the Sinai area (about 60.000 sq. Km. or 15.000.000 acres) our knowledge of the soils in El Qusaima is practically inadequate. In his very rapid reconnaissance survey of the soils in Northeastern Sinai, El Gabaly (1954) attempted to reveal the broad framework of the soil divisions which are displayed in that area. Although most of his work was concentrated in the region to the north of « El Halal Ridge», El Gabaly

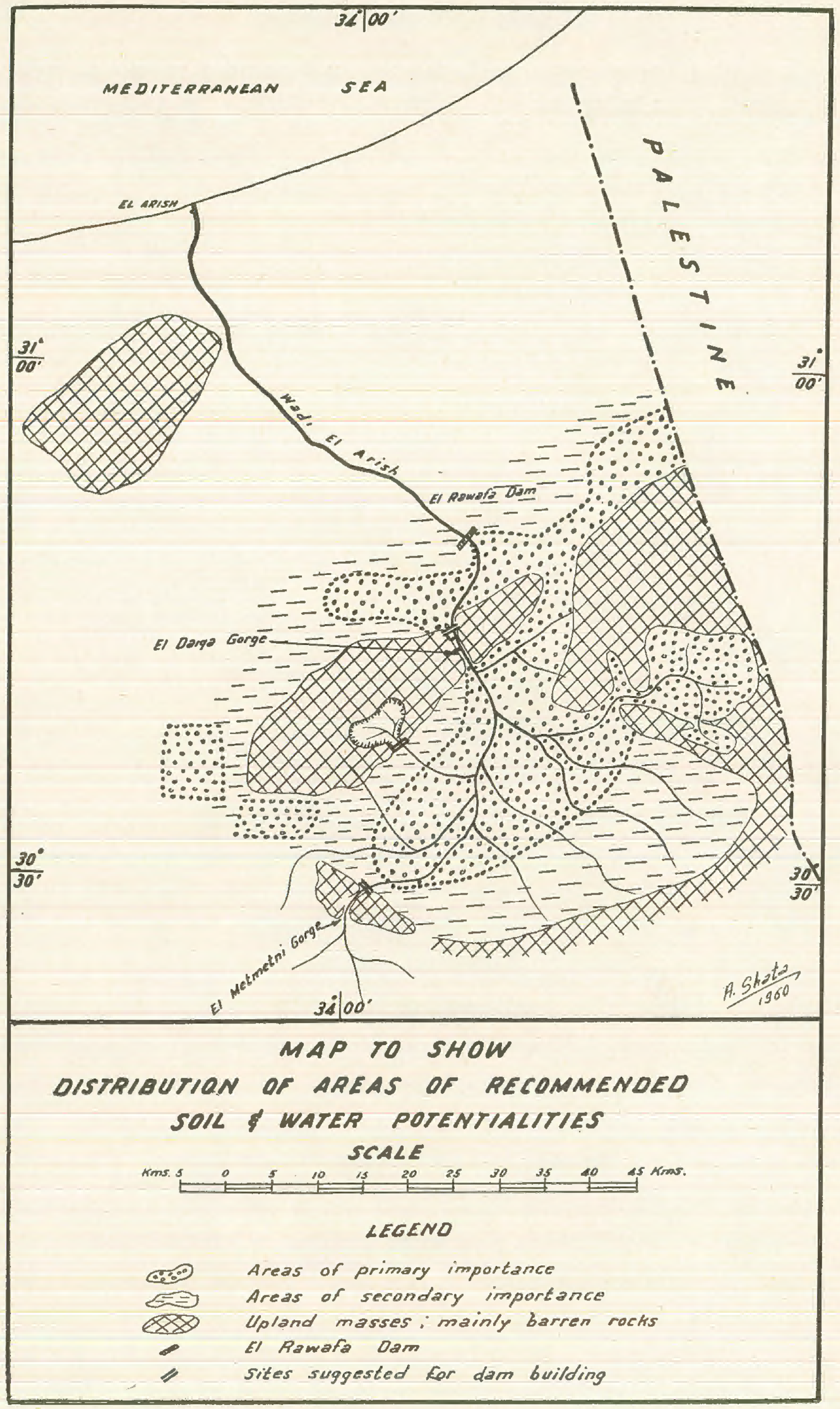

Fig. 4.

included most of our area in his soil map and referred to the following soil divisions :

1. Rough Broken mountain lands (comprising the « Eastern Dissected Tableland Region» and « El Halal Ridge»).
2. Soils surrounding mountains (comprising the « Foothill slopes» of the « Tableland» and the « Ridge»).
3. Alluvial soils of Wadi El Arish.
4. Inland sandy soils-gravelly phase.
5. Sandy soils of wind origin.
6. Inland sand dunes.

In evaluating the agricultural possibilities of that wide area, El Gabaly remarked that the occurring soils have a general « high potential productivity» and the area is recommended for fruit cultivation and whereever the water supplies are limited olive trees are of primary importance. The only other soil survey done in Northeastern Sinai was that made by Abdel Salam (1960) and was restricted to Wadi El Arish Basin in the region north of El Halal Ridge. In this region, the soils are subdivided into two main classes; 1) alluvial soils (old alluvial deposits and recent mixed deposits); and 2) micellaneous land types. These two classes belong to a major group which he termed the « Mediterranean Serozem». Although the work of Abdel Salam was more detailed than that of El Gabaly, their conclusions regarding the land capability are approximately the same.

Still, we have to admit that our knowledge of a 100.000 acres of arid lands found in El Qusaima area and which have apparent soil potentialities, is quite vague. It is accordingly advisible to make a detailed and systematic study of the occurring soil accumulations which are particularily noticeable in « Wadi El Arish Basin» to the south of El Daiqua Gorge, in the shallow erosional depressions found in the « Tableland Region» which are best examplified by « El Sabha Basin», « El Abyad Basin» and eventually «Umm Hashim Basin», and in the lowland regions bounding « El Halal Anticlinal Ridge» and which are best examplified by Wadi El Hossani, Wadi El Mitmetni, Umm Shihan and Abu Yentul. Application of the modern techniques used in studying

the soils of similar arid regions, details of which are discussed in the UNESCO book on the future of Arid Lands (edited by G. White, 1956), must be taken into consideration.

Then, what about the water potentialities of El Qusaima area? These are not fully understood owing to lack of any detailed exploratory work. In his report on the « Water Resources of North and Central Sinai», Mr. W. E. Wallis (Chief Geologist of the standard Oil Company of Egypt, 1945) referred in brief to the geological situation and nature of the water supplies of some of the water points which we have in El Qusaima area. Also Hellstrom (1953) gave a very short account of the ground water conditions in the localities which he visited in Northeastern Sinai (El Qusaima included) during the expedition of the Desert Institute. Quoting some of the words of Mr. Hellstron on page 16 we read « During the expedition valuable information was obtained about the hydrology of Northeastern Sinai. Much additional investigation is required, however before a reliable estimate can be made of the amount of ground water available and the quality of the water». The work of Paver and Jordan (1956) in Northeast Sinai was localized to the coastal strip and, therefore, did not add much to our knowledge about the water potentialities of El Qusaima area. However, facts which we have from the study of the geology and geomorphology of that area point to the occurrence of a number of « subclosed hydrographic basins» which may be suitable for ground water accummulation. Some of these basins are also excellent sites for the conservation of surface water. In this area, three main basins and three micellaneaus basins are distinguished (Fig. 5). The following is a brief description of these basins :

1. *The southern sector of Wadi El Arish;* this extends between El Mitmetni Gorge and El Daiqa Gorge and has on area of about 1000 sq. Km. This basin constitutes only a small portion of the great synclinal area between « Rumman Upfold» and « El Halal Upfold». Its surface is dominated by Upper Cretaceous chalks and limestones but towards the western portion remnants of Lower Eocene limestones and Palaeocene shales are preserved on top of the Cretaceous. Within this big basin, practically no water points are detected. Attempts, however, were made

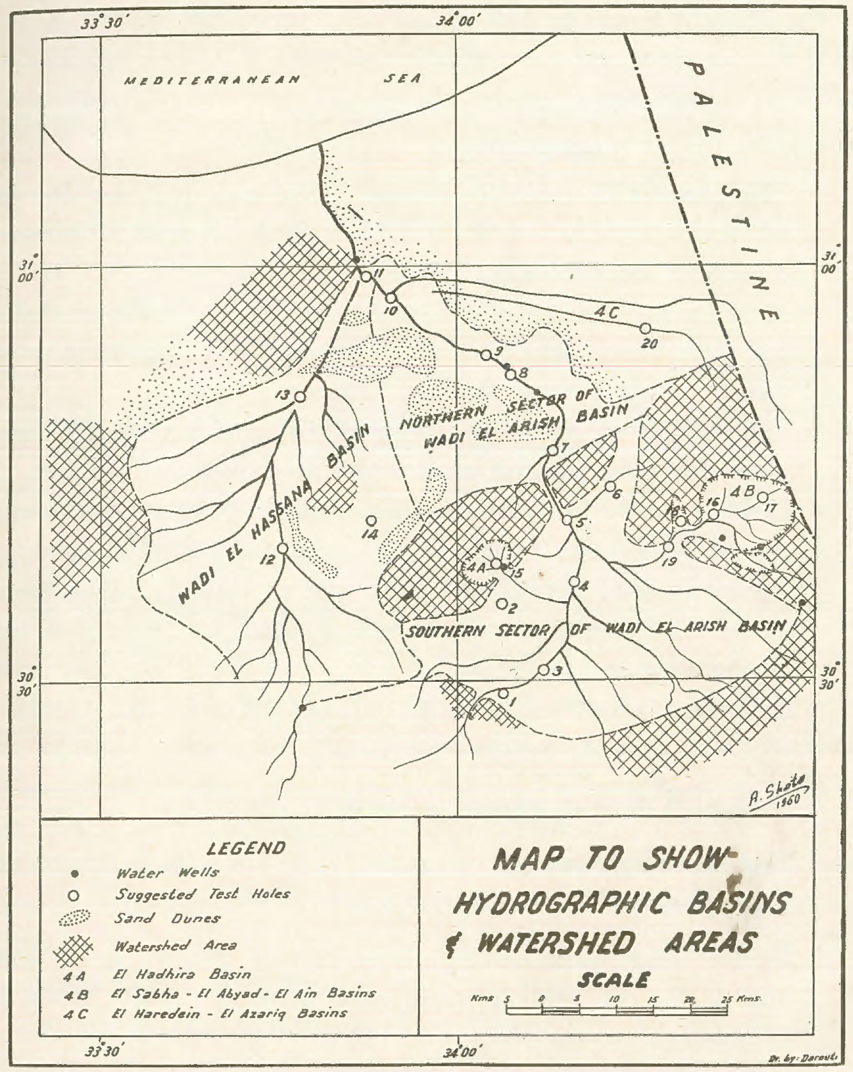

Fig. 5.

in 1947 to drill for water in the northern portion of this basin in close proximity to the inlet of « El Daiqa Gorge» but these were not successful. At this site, 40 m of alluvium were drilled, but no water bearing layers were reported. This, however, may not eliminate the importance of this site for water finding as deeper drilling is suspected to pass through suballuvial gravels which may make an important aquifer.

The importance of this basin as a water prospecting region is due to a number of factors; these include :

a) This basin constitutes a portion of the great syncline between El Halal and Rumman upfolds.
b) This basin is traversed by Wadi El Arish master stream and its tributaries some of which have their intake area located many Kilometres away from its center.
c) The surface of this basin is dominated by Upper Senonian chalks and Lower Eocene limestones which are water bearing strata in many places in Central Sinai (Nekhl, El Hassana ... etc.).
d) The possible occurrence of old suballuvial gravels along the main channel of Wadi El Arish which may make an excellent aquifer.
e) Last but not the least, the inclusion of this basin between two main gorges (35 Km apart) along the main channel of Wadi El Arish. During the flood periods the water passing through the southern gorge (El Mitmetni) tends to relax on the surface behind the northern gorge (El Daiqa) for some time and thus may have the chance to percolate through joints or fissures into the Senonian and Eocene chalks and limestones.

The following are our recommendations for this basin :

a) Shallow drilling (50 to 100 m depth) in the sites indicated on Figure No. 5 (Wells 1, 2, 3, 4, 5 and 6 inclusive).

b) Surface water conservation between the two gorges; the system involves the construction of two earth dams, one at the outlet of El Mitmetni and the other one at the outlet of El Daiqa, and a number of dykes for water spreading.

c) A reconnaissance geophysical survey by resistivity method whenever possible.

2. *The northern sector of Wadi El Arish Basin;* this comprises the portion of Wadi El Arish basin which is included between « El Daiqa Gorge» and « Lihfin Gorge» close to Risan Aneiza. This basinal region occupying an area of about 500 sq. Km (120.000 acres) is traversed by Wadi El Arish in a northwest direction. The surface of this basin is dominated by Quaternary alluvial and aeolian deposits but in its southern portion scattered Cretaceous, Palaeogene and Neogene outcrops are known (Shata, 1959). Within this basin few wells, having a limited supply of water, are known (3 wells at Abu Eweigela, 1 at Awlad Ali and 3 at El Magdaba). The strata of hydraulic interest in these wells and in the area in general are as follows :

a) The Lower Cretaceous sandstones (at Lihfins, some 500 m below the surface).

b) The Cretaceous and Eocene limestones and chalks (between El-Daiqua and Awlad Ali).

c) The Pliocene deltaic gravels particularily noticeable in the area between Abu Eweigela and El Magdaba.

d) The Quaternary gravels filling the present channel of the Wadi (Awlad Ali, El Magdaba and Thamail El Nusiyat).

In this basinal region, there exists El Rawafa Dam which was constructed in 1947 with the object of checking the flood water of Wadi El Arish. The initial capacity of the reservoir behind the dam has been estimated as 5 million cubic metres (due to silting processes, the present capacity does not exceed 2 million cubic metres). Between El Rawafa and Lihfin, a number of low earth dams and dykes are witnessed along the present channel of the « Wadi » and were presumably made prior to the construction of El Rawafa Dam.

In evaluating the water potentialities of this region, it will be subdivided into the following two unequal portions :

a) A smaller portion; comprising the region behind El Rawafa Dam which extends southwards up to the outlet of « El Daiqua Gorge». For geological and hydrological reasons, this portion may have relatively high water potentialities. Test boring at the junction of the three main subsequents (Umm Shihan, Umm Saura and Abu Yentul) with the master stream of Wadi El Arish, is needed—Well No. 7, Fig. 5 (resistivity surveys are not recommended immediately).

The occurrence of the Palaeocene shales between the Eocene and the Cretaceous limestones and chalks may cause some local interruptions, but would not eliminate the importance of the region.

b) A bigger portion; lying to the north of El Rawafa Dam. The construction of such a dam has certainly affected the regime of the few wells located in that region. Notwithstanding this phenomenon, we might as well refer to the following points;

I — Between El Rawafa and Lihfin, Wadi El Arish has been described as a simple consequent stream, but eventhough it is connected (particularily on the eastern side) to a number of short subsequents which during the flood periods contribute to the water supply of the « Wadi» and thus may lead to the replenishment of the strata underlying the present channel.

II — The deltaic deposits reported at Awlad Ali and El Magdaba may have a wider lateral distribution underneath the young alluvium and thus we expect that some of the gravel phases which constitute such deposits can make an important aquifer.

Between El Rawafa and Lihfin shallow test boring (maximum depth 50 m) is needed at Awlad Ali (Well No. 8), El Magdaba (Well No. 9) and Hareiden (Well No. 10). A deeper bore (500 m depth), may also be needed at Lihfin (Well No. 11) to test the Lower Cretaceous sandstones. Between Abu Eweigela and El Magdaba, resistivity surveys are recommended in order to learn more about the lateral distribution of the deltaic gravels.

3. *Wadi El Hassana Basin;* this occupies the synclinal area between « El Halal Ridge» and « El Maghara-Risan Aneiza Ridge». In this basin, although the directive water channels are ill-defined, we have the impression that these are connected to one main channel (Wadi El Hassana) which joins Wadi El Arish on the western side at a point lying to the south of Lihfin Gorge. The importance of this basinal region is due to the following reasons;

a) It occupies a wide synclinal area.

b) It is traversed by a complicated denderitic pattern which drains a variety of watershed regions including El Maghara, Risan Aneiza, Yelleg, El Halal and Libni.

c) The surface is mostly occupied by Eocene and Cretaceous calcareous layers which have a reasonable water holding capacity through joints and fissures (in the northeast portion, Palaeocene and Neogene clays may be found underneath the modern alluvial and aeolian deposits and thus may reduce the importance of such portion as a water prospecting locality).

Within this basin test boring was tried in some places but the results are not known to us. Additional test bores must be tried also in this basin, particularily in the local synclines between El Halal and El Maghara (Well No. 12) and between Libni and Risan Aneiza (Well No. 13). In case sound results are obtained, a resistivity survey may be recommended. Another hole (Well No. 14) may be needed in the syncline between El Halal and Libni.

4. *Micellaneous Basins;* these include :

a) *El Hadhira Basin;* This occupies the erosional cirque on the crest of El Halal anticline and is mostly occupied by Nubian type strata which are in many places covered by talus deposits and boulders. El Hadhira is characterized by a well developed denderitic drainage pattern joining Wadi El Hadhira which is an important subordinate of Wadi El Arish. Within El Hadhira Basin, nine shallow water wells are present (two of which have silted up as mentioned by Hellstrom, 1953). These wells bail their water from the Cretaceous Nubian layers and not from the modern wadi gravels, as stated by Hellstrom. In several places of Sinai, the Nubian layers are reported as an excellent aquifer, and thus we may be justified in assuming a rather high water potentialities of El Hadhira. Cleaning and deepening the occurring wells is, therefore, suggested. A deep test hole ($\pm$ 200 m depth, Well No. 15) is also needed to test the underlying sandstone members belonging to the Lower Cretaceous and the Upper Jurassic.

b) *El Sabha-El Abyad-El Ain Basins;* these represent shallow hydrographic depressions occurring within the « Dissected Tableland Region ». As this region constitutes only a portion of the great « Synclinal Plateau » between Rumman and El Halal upfolds we expect that these basins will have rather important water possibilities. From Rumman upfold this plateau descends towards El Qusaima area i.e. in a westward and northwestward direction from an altitude of + 1000 m to + 400 m. This synclinal Plateau, having an area of about 1500 sq. Km., forms an excellent catchment « Basin » which is « undoubtedly influencial on the water supply of the whole area east of El Halal upfold ». The water is thought to « percolate through joints and solution channels » in the Eocene limestones, « probably to the top of the Esna Shales » belonging to the Palaeocene, and which « form an impervious surface and then by gravity down dip in a northwest direction to feed the few wells known in that area » as examplified by Ain El Gedeirat and Ain Qadis. Even the water which is reported in the Upper Senonian chalks of El Qusaima Well is derived from « a very shallow water-table probably seepages from Ain El Gedeirat ». As indicated on our geological map, El Sabha and El Abyad basins are eroded down to the Upper Senonian chalks. This formation, holding water in several places in Central Sinai and also in El Qusaima itself, must be tested carefuly. Three sites are, therefore, selected for test boring; one located due north of El Qusaima at the junction of Wadi El Sabha with Wadi El Wabsi (Well No. 16), another one in Wadi El Sabha at the foot Gabal El Sabha itself (Well No. 17) and a third one in Wadi El Abyad to the north of El Qusaima road (Well No. 18). A fourth test hole may be suggested in Wadi El Muweilah at the foot of Gabal Mushraq (Well No. 19). In El Ain Basin on the other hand, erosion has gone down to the Palaeocene shale, which is practically impervious. The occurrence of such shales on the surface may reduce the water potentialities of the underlying Upper Senonian chalks. Still remain the edges of Eocene escarpment which may be considered important as water can be held at the contact between the Palaeocene shales and the Eocene limestones.

c) *El Hareiden-El Azariq Basin;* Wadi El Hareiden and Wadi El Azariq run in an east-west direction and join Wadi El Arish on the eastern side, in the region to the south of Lihfin Gorge. These two wadis have their intake areas located in « El Qusaima Dissected Tableland Region » and also in the highlands of El Naqab. The strata of hydrologic interest in this basin comprise the Eocene limestones which underlie the drift sand cover in the eastern portion, and the Quaternary fan deposits which dominate the western portion. Verbal information from the local beduins points to the fact that for many years these two wadis have not been flooded which may mean that their water is partly or totally conserved in Palestine. However, we can also add that the local precipitition on Gabal El Amr, may contribute to the water supply of this basin. It is, therefore recommended to drill at least two test holes; one hole in the synclinal area between Taret Umm Basin and El Khabra (Well No. 20) to test the Eocene strata and another hole to test the Quaternary gravels close to the junction of Wadi El Hareiden with Wadi El-Arish (Well No. 10).

ACKNOWLEDGMENT

The writer wishes to express his thanks to Mr. M. Ghourab for verbal information on the occurrence of the Neogene formations in North Sinai and to Mr. M. Rafik Salem (Geology Section-Desert Institute) for his help in preparing the different figures attached to this paper.

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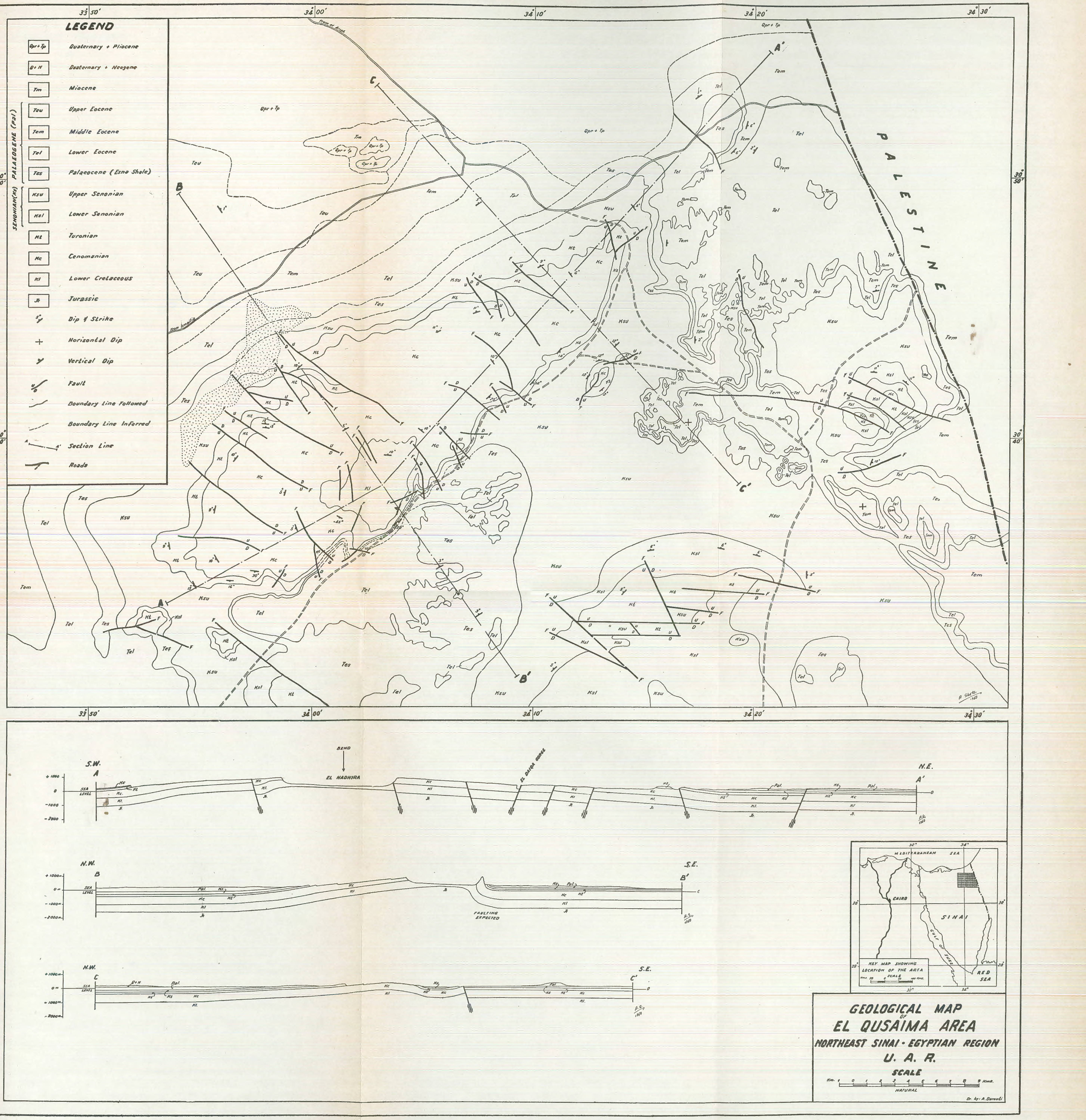
MAP 1


LEGEND
Qpr + Tp Quaternary + Pliocene
Q + N Quaternary + Neogene
Tm Miocene
Teu Upper Eocene
Tem Middle Eocene
Tel Lower Eocene
Tes Palaeocene (Esna Shale)
PALAEOGENE (Pal)
Ksu Upper Senonian
Ksl Lower Senonian
SENONIAN (Ks)
Kt Turonian
Kc Cenomanian
Kl Lower Cretaceous
Js Jurassic
Dip & Strike
Horizontal Dip
Vertical Dip
Fault
Boundary Line Followed
Boundary Line Inferred
Section Line
Roads
PALESTINE
S.W.
N.E.
BEND
EL HADHIRA
EL DAIQA GORGE
SEA LEVEL
FAULTING EXPECTED
N.W.
S.E.
KEY MAP SHOWING LOCATION OF THE AREA
MEDITERRANEAN SEA
CAIRO
SINAI
RED SEA
GEOLOGICAL MAP OF EL QUSAIMA AREA
NORTHEAST SINAI - EGYPTIAN REGION
U. A. R.
SCALE
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Dr. by: A. Daroali

MAP 2

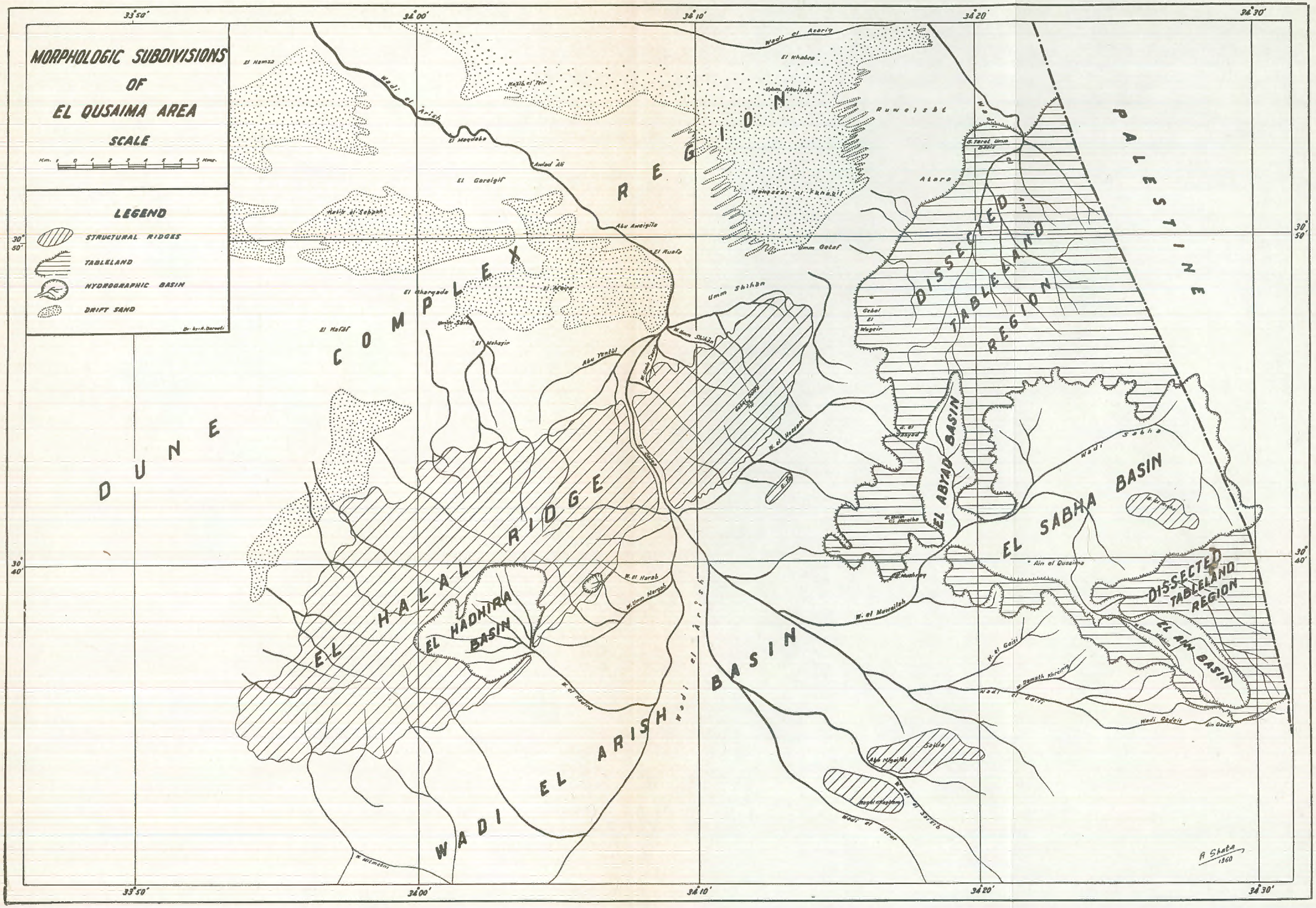

MORPHOLOGIC SUBDIVISIONS
OF
EL QUSAIMA AREA
SCALE
LEGEND
STRUCTURAL RIDGES
TABLELAND
HYDROGRAPHIC BASIN
DRIFT SAND
DUNE COMPLEX REGION
DISSECTED TABLELAND REGION
PALESTINE
EL HALAL RIDGE
EL HADHIRA BASIN
EL ABYAD BASIN
EL SABHA BASIN
EL AIN BASIN
WADI EL ARISH BASIN
Wadi el Arish
33°50'
34°00'
34°10'
34°20'
34°30'
30° 50'
30° 40'
A. Shata 1960

Photo 1. Distant view of El Halal Anticlinal Ridge; note El Daiqa notch on the left hand side and the alluvial deposits in the foreground; view looking south.

(Photo, by O. Draz).

Photo 2. Southern enterence of El Daiqa Gorge in the Cenomanian limestone; note the alluvial deposits of Wadi El Arish in the foreground; view looking north.

(Photo, by M. Mitwalli).

PHOTO 3. El Hadhira erosional cirque; note the boulders and gravels in the foreground and the tilted Cretaceous strata in the background, these are broken by Wadi El Hadhira, to the left; view looking south.
(Photo, by M. Mitwalli).

PHOTO 4. Vertical strata of Cenomanian age, Southeastern portion of El Hadhira; view looking west.
(Photo, by M. Mitwalli).

PHOTO 5. Eocene strata bordering Wadi El Gedeirat; palm grooves in the bottom of the valley; view looking east.

(Photo, by M. Mitwalli).

PHOTO 6. Miocene marls overlain by Pliocene conglomerates; out crop forms an isolated flat topped hill in Wadi El Arish at Awlad Ali; view looking west.

(Photo, by M. Mitwalli).

PHOTO 7. Pliocene conglomerates cropping out in the bed of Wadi El Arish at El Magdaba; note the Lower terrace of the wadi in back ground; view looking northeast.

(Photo, by M. Mitwalli).

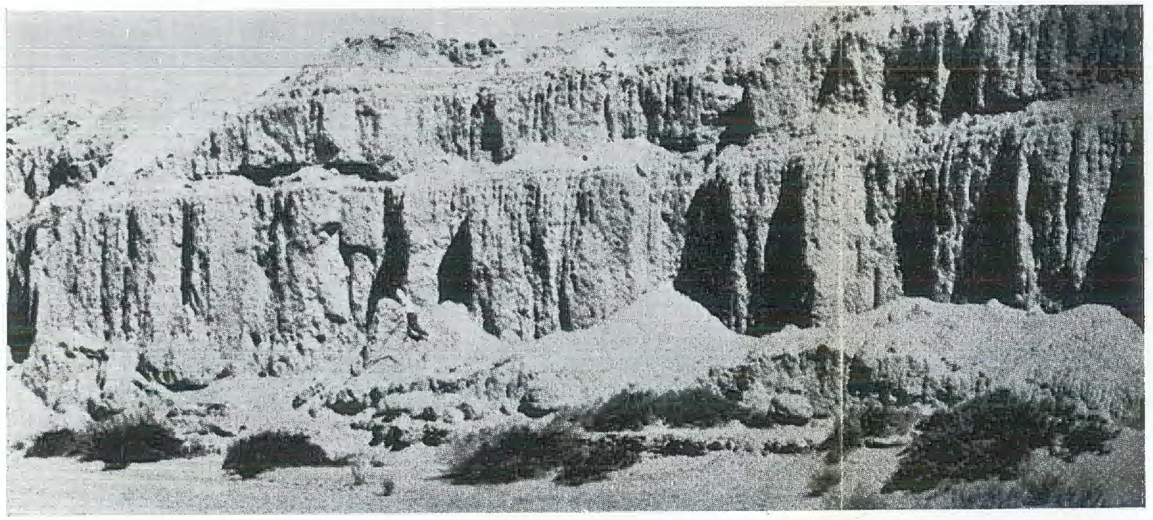


PHOTO 8. Young alluvial deposits forming the Middle Terrace of Wadi El Arish close to Wadi Hareiden; view looking north.

(Photo, by A. Shata).

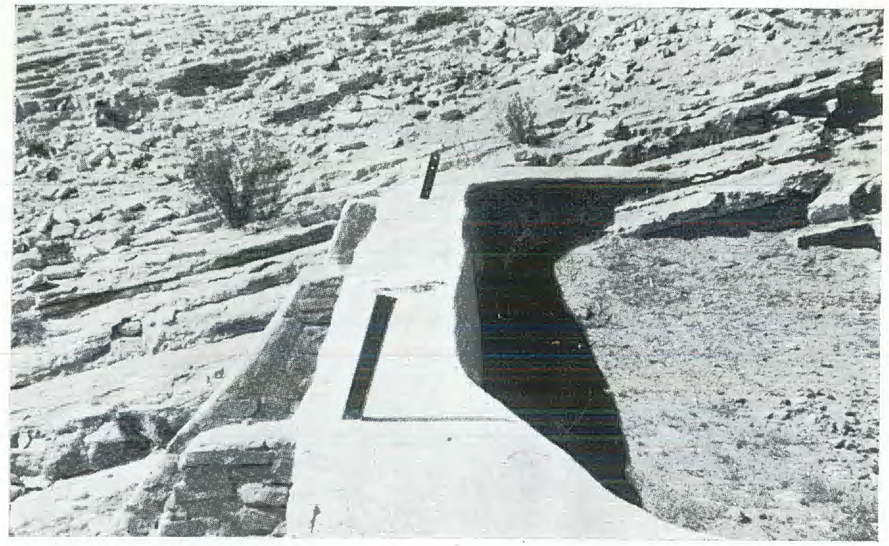


Photo 9. A small dam built on one of the transversal subsequents draining the southeast portion of Gabal Dhalfaa (good example for soil and water conservation).
(Photo, by M. Mitwalli).

Photo 10. Old dam in Wadi El Gedeirat; silted up completely.
(Photo, by M. Mitwalli).

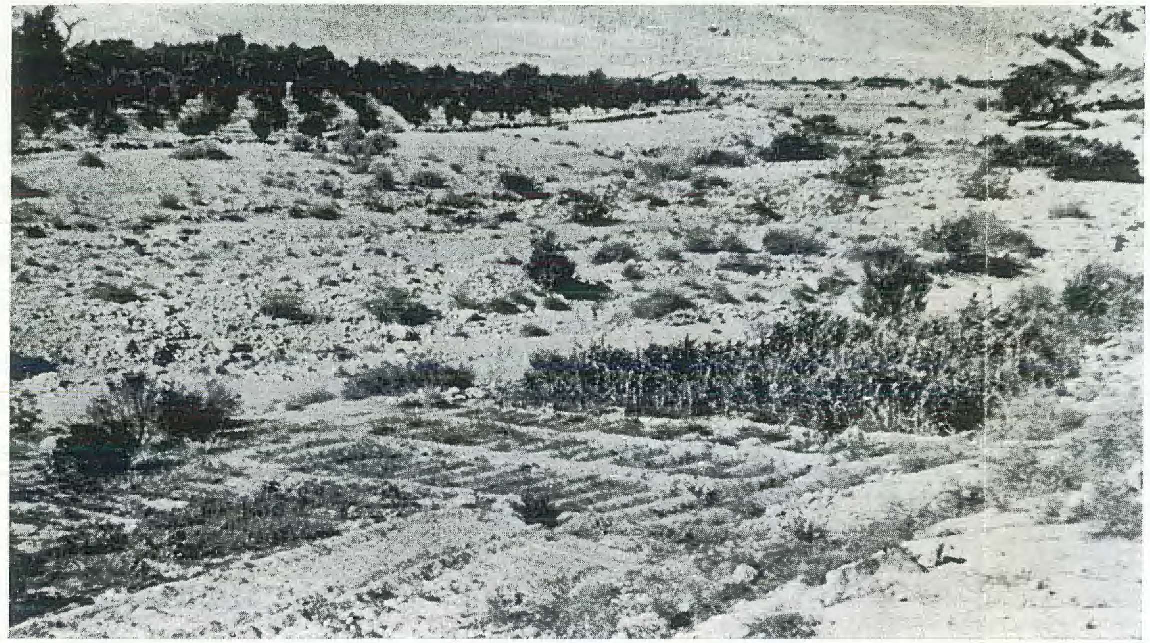


PHOTO 11. Cultivation in Wadi El Gedeirat.

(Photo, by M. Mitwalli).

PHOTO 12. Beduins watering at El Hadhira Wells.

(Photo, by M. Mitwalli).

SOIL SURVEY, CLASSIFICATION AND MANAGEMENT OF THE MARIUT AGRICULTURAL PROJECT

BY

AHMED G. ABD EL-SAMIE

(PH. D., SOIL SCIENCE)

INTRODUCTION

The coastal zone of the western desert constitutes a semarid area which is inhabited by beduin shephards and cultivators who live a nomadic life. History records show that this area which extends between; Alexandria and Sallum was once thickly populated and agriculturally prosperous. Remnants of old dykes, cisterns, wells, and temples indicate its full utilization in the past, as it was termed as part of the « grannary of Rome». At the present time, this large area supports only few herds of grazing camels, sheep, and goats. Some alluvial benchlands are cultivated by primitive methods and seeded to barley, Only small fig and olive orchards are found in wasis (small vallies) where the soil receives more of the runoff rain water, and thin layers of fairly good underground water are found within few meters from the surface.

Some studies have suggested that a change of weather has occured, and that the destruction of the area is due in part to the aridity of the climate which was once more humid. Yet, the structures which were built by the Romans to conserve and utilize surface and subsoil waters reveal that the climate at that time was not much different from it at the present time. Besides, soil profile characteristics also suggest that the climate of this zone has always been on the arid side. It is assumed, therefore, that the main factor for its deterioration is the misuse by man. Bad management, particularly uncontrolled grazing, has left the natural vegetation almost completely denuded, and the soils severely eroded.

Few projects were proposed for the agricultural development of the area by shifting parts of it from the present status of limited dryfarming practices in winter to an all-year irrigation farming. For this purpose, investigations on the geology, hydrology, soils, and plant ecology were carried out, along with horticultural experiments. These investigations revealed the presence of few perched water basins, and significant layers of underground water that can be pumped out for drinking and small-scale irrigation agriculture. The utilization of this underground water is now developing, and fairsize farms are established at Mersa-Matruh, Ras El-Hekma, Fuka, Burg El-Arab, and El Amereya.

The prevailing conditions of the Mariut area required special considerations for its future agricultural development. The existing shallow wells indicate that the amounts of underground water are small and of poor quality. Yet, this area constitutes big acreage of fairly good soil, besides, it is located directly west of the Nile delta, close to Alexandria, and on the main desert road. These factors have given the area more concern in the immediate development projects of the government. Any major agricultural expansion in this direction would have to depend, however, on irrigation from surface waters. The two main schemes which were suggested for this purpose are :

First : to use the western arm of lake Mariotis as a reservoir for storing the excess flood waters of the Nile. Water can be pumped again for irrigating the surrounding areas. This suggestion was rejected because of many technical difficulties, besides, it is also mentioned that the « High Dam» will save the surplus flood waters.

Second : to divert the drainage water of El-Omoom drain and pump it directly to irrigate the arable areas instead of pumping it to the Mediterranean Sea. Data from El-Max pumping station near Alexandria showed that its discharge ranges between one and six million cubic meters per day. The chemical analysis of the water indicated that it contains about 6000 parts per million of water-soluble-salts at the El-Max outlet, and 3000 pp.m at the suggested diversion point, few kilometers south of lake Mariotis.

The second project gained more attention in the past five years, and more studies on the soils and drain waters were therefore recommended.

Location :

The project area constitutes part of the eastern border of the western desert, Mediterranean littoral region. It is included between kilometers 920 north of base. Latitude 30°51′ N and longitude 29°45′ E cross almost at the centre of the studied area.

The current investigation covered approximately 129.000 feddans included in four major areas, namely : Kandara, Amereya, Mena, and Bahig. All of it lie west of the Cairo-Alexandria main desert road between kilometers 166 and 188 (distances from Cairo). Its western boundary is the imaginary N-8 line crossing Bahig village (key map).

Field Work :

The field work was conducted on a semi-detailed basis, and included testing a number of about 509 profiles to depths of 4 to 5 feet. The distances between these profiles varied, according to possible changes in their characteristics, between 500 and 1500 meters. All profiles were described, and representative samples were collected for various laboratory analysis. The 1:25.000 topographical maps published by the Egyptian Department for Survey and Mines in 1940 were used as base maps because aereal photographs of reasonable scale were not available at that time.

The completion of the job required two teams for soil surveying, each with a car, a trained surveyor and his assistant, and about six labourers for a period of approximately 35 working days. These days were distributed in April, May, and June 1955, and in February 1956. Most of the field investigations in the western part (Mena and Bahig areas) were carried out during the latter month when the soil was fairly wet, therefore allowing for the regular screw-auger testing instead of pit-digging.

Participated in the field work were; M. A. Abd El-Salam (Ph. D.), A. Mitkees (M. Sc.), and A. G. Rashid (B. Sc.), members on the staff

KEY MAP (1)

SHOWING LOCATION OF THE PROJECT AREA

SCALE 1 : 2.000.000

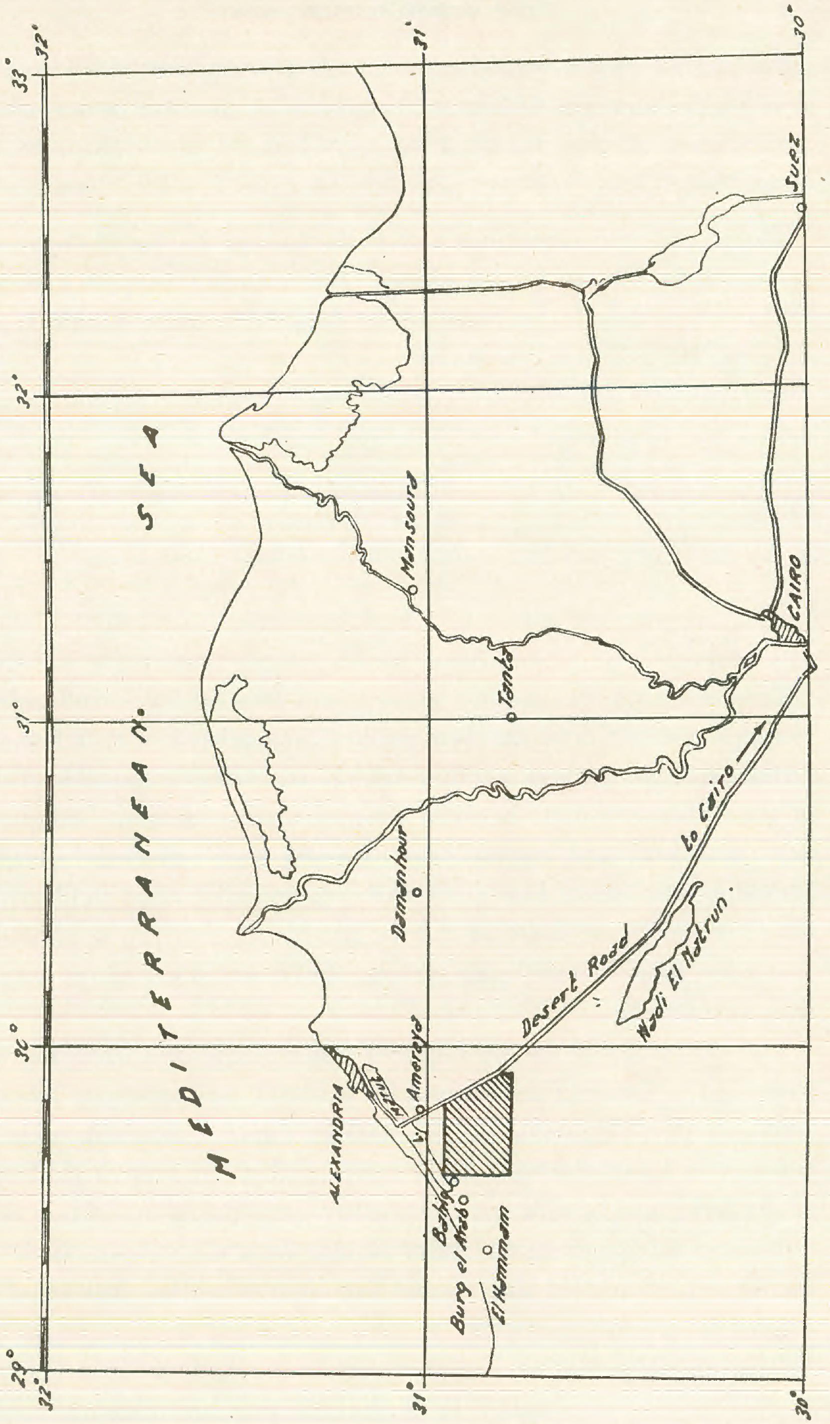


Fig. 1.

of the soils department at the Desert Institute. Helped in profile locating were Dr. A. Shata, chief geologist, and engineer M. Sammy of the hydrology department who were were doing research in their respective lines at the time this investigation was carried out.

To all of them, I extend my sincere thanks and appreciation.

KEY MAP (2)

SHOWING ORIENTATION OF THE FOUR SURVEYED AREAS

SCALE 1 : 200,000

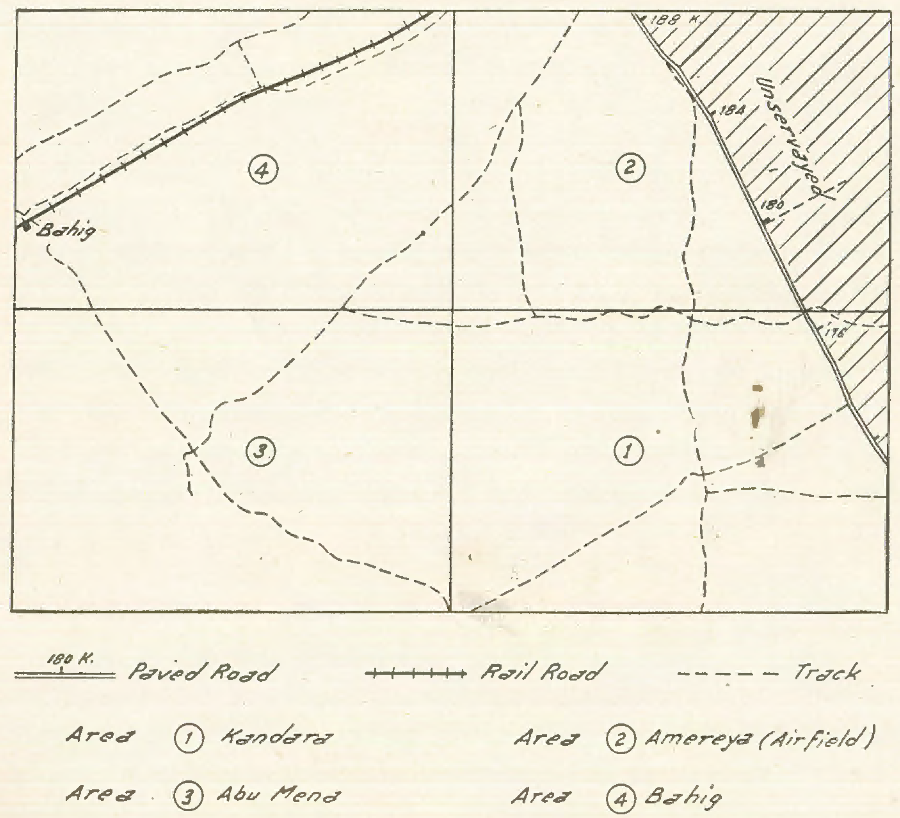


Fig. 2.

Geology and Geomorphology :

The geological features of the Mediterranean littoral have been discussed by many authors during the past sixty years. The most recent study was conducted by Shata (7) who reported comprehensively on «The physiography of El-Amiria-Mariut Area». In this area, Shata distinguishes two main topographic features :

a) «The Mediterranean Foreshore Plain» which is crossed by a number of alternating parallel ridges and depressions oriented in a NE-SW direction. The depressions were formed by a slow continental subsidence, while the three known ridges are of non-marine origin and were formed by wind action along the receeding shore. These ridges are composed of oolitic sand and oolitic limestone having a recrystallized top limestone of variable thickness and hardness.

b) The relatively elevated plateau, «Mariut Table Land» with a v-shaped valley, Abu-Mena Basin, descending in a NE-SW direction. This tableland is an extension of the Lybian plateau and includes the southern portion of El-Amereya-Mariut area which contains the main body of the currently investigated project. The surface is a calcareous type, made of brickred and brown sandy limestone of probable Pliocene and Plio-Pleistocene age, containing occasionally recent land shells of the type Hellix in the surface layers. Morphologically, Shata adds, the Abu-Mena basin represents a shallow erosional depression traversing the Mariut table-land in a NE direction.

Climate :

Systematic comprehensive records for the area are lacking, and the relatively limited amount of information which could be obtained referred to rainfall at Burg El-Arab and El-Amereya farms.

The climate of the area belongs to the Mediterranean type which is characterized by dry warm summers and short rainy winters. Rainfall takes place mainly during the four winter months of November, December, January and February, the following table shows the monthly averages

for rainfall at El-Amereya village and the Burg El-Arab agricultural experiment station, for several years. More recent data for rainfall at the rainfall at the latter station are also presented.

MONTH	AMEREYA				BURG EL-ARAB				
	(1918-1924)		(1921-1952)		1955	1956	1957	1958	1959
	max. mms.	min. mms.	max. mms.	min mms.	total mms.	total mms.	total mms.	total mms.	total mms.
January	50.0	38.0	48.0	41.0	—	57.5	74.0	69.5	39.5
February	41.0	30.0	37.0	23.0	—	14.5	41.0	55.0	84.5
March	16.0	6.0	23.0	7.0	—	12.5	11.0	—	—
April	20.0	2.0	12.0	2.0	—	—	5.0	—	—
May	5.0	1.0	9.0	1.0	—	—	—	—	—
June	tr.	tr.	tr.	tr.	—	—	—	—	—
July	tr.	tr.	tr.	tr.	—	—	—	—	—
August	tr.	tr.	tr.	tr.	—	—	—	—	—
September	4.0	tr.	6.0	tr.	—	—	—	—	—
October	12.0	1.0	35.0	7.0	6.0	3.0	86.5	—	—
November	28.0	19.0	65.0	29.0	97.5	2.0	43.5	—	—
December	57.0	39.0	50.0	37.0	69.0	79.0	45.5	20.0	—

The total precipitation per rainy season for the last few years is as follows :

season	total rainfall
1955-1956	257 mms.
1956-1957	215 mms.
1957-1958	240 mms.
1958-1959	144 mms.

The amount of rainfall decreases as one proceeds inland. Within 80 kilometers from the coast, rainfall decreases to about 25 mms, southward of which it becomes negligible on the inland desert plateau. Detailed data indicate that the distribution of rain during the rainy months is not very favourable as it usually comes in flashes which induce surface runoff and infrequent floods. Sheet, rill, and gully erosion take place, and signs of active sheet and rill erosion are still present.

Temperature records show that the lowest values are reached during the rainy season, Dec. to March, while the highest temperature values prevail from April to September. The following table includes data of temperature, relative humidity, evaporation and wind velocity at Alexandria airport which is approximately 20 kilometers east of the investigated area. These values are the averages of 14 years, from 1942 until 1955.

MONTH	Temperature °C			evapn. (1953)	wind velocity	rainfall total	Relative humidity		
	normal	max.	min.	mms./day	kms./hour	mms.	morning	mid-day	eve
January	13.6	18.1	9.2	5.0	15.0	41.9	78	67	54
February	14.2	19.0	9.6	6.0	16.5	27.7	76	73	51
March	15.7	23.2	13.3	6.2	17.0	12.8	71	73	51
April	18.1	23.2	13.3	5.6	15.2	3.0	68	74	52
May	21.3	26.4	16.6	7.1	14.8	1.8	68	77	54
June	24.1	28.2	20.2	5.8	14.8	tr.	69	79	61
July	26.0	29.5	22.7	5.8	15.8	tr.	71	79	64
August	26.4	30.3	22.7	6.5	13.0	0.6	71	79	62
September	25.4	29.4	21.2	6.3	11.0	0.5	69	74	58
October	22.7	27.8	17.7	5.8	9.6	6.9	70	73	54
November	19.1	24.2	14.7	5.0	12.8	35.1	76	76	54
December	15.2	20.1	11.2	3.4	13.0	60.3	81	78	56

Vegetation :

The studies of Tadros (9) on the vegetation of the Mediterranean coastal strip revealed four distinct zones included in only one phyto geographical region. These zones are; the oolitic sand dunes, the rocky ridges, the salt marshes, and the cultivated land. In his discussion on the plant communities of each of the above-mentioned zones, he reported that two communities dominate in the Mariut table-land.

1. *In the cultivated barley areas :* plant association Achilletum Santolinae Mareoticum as dominant, two subdivisions;

a) Chrysanthenotosum coronariae, and

b) Arisaretosum vulgaris.

2. *In the non-cultivated areas :* the following communities ;

a) Thymelie hirsuta,

b) Plantagineto-Asphodeletum microcarpi, and

c) Anabasideteum articulati.

The same author reported that the association Thymelaea hirsuta and Gymnocarpus decander occupies mainly the rocky ridges, while that of Plantago occurs on shallow pebbly soil overlying rocky limestone hills. The association Anabasis is fairly common on the higher plateau of compact, relatively heavy, and sometimes gravelly soils.

In the areas of higher elevation and moderate salinity, the following communities were described :

Salicornieta-Limonietum pruinosae.
Arthrocnemeto-Limoniastretum monopetali.
Zygophyllum albi, and
Hygacum spartum.

Soil Survey :

The importance of soil survey and classification has gained considerable attention in Egypt only recently, especially with the planning of some major agricultural development projects in both the desert and the lower delta regions. Nearly all soil survey investigations which were carried out in the past ten years, although gave valuable information about the soils, yet they lacked the important conclusions which include the establishment of the units of soil classification, the soil type. Correlation between various reports on similar areas and soils was, therefore, hard to reach. It may be true to say that there were not enough data accumulated to help decide on the soil types or series, particularly with the delta alluvial soils. Yet, in the desert and semi-desert regions of Egypt, enough information has become now available to reveal major differences in soil profile characteristics. Needless to say that in order to follow the systems of classification which are adopted in other countries, the establishment and nomenclature of soil series must be considered as the major aim in our present soil survey work throughout the country.

This not only facilitates the continuation and progress of the survey, but it also contributes a great deal to the compilation of a soilsmap of Egypt.

During the scientific investigations of the soils in the Mariut area, the author based his mapping on soil series identification. Previous reconnaissance survey in the coastal zone, and the semi-detailed soil survey of the Ras el-Hekma and Fuka areas offered valuable data about the formation and characteristics of these soils. In reporting about the Ras el-Hekma soils (3), they were described as; Type I, II, III; etc. In the Fuka soil survey report (2), the same soils, and few others, were described again, and series names were suggested for them. The current report uses series names directly with more detailed description.

The series names were chosen to indicate names of local significance although they should be used wherever the series are found, under similar soil forming conditions. For example; deep alluvial soils with neither carbonate accumulation zones nor lime concretions in the first five feet were always located in depressions or inside man-made earth enclosures. It has been reported that these enclosures were built by the Romans to collect and conserve rain water, and are called « Karms» or « Korums». Therefore, soils of this nature belong to the « Karm» series. Similarly, soils with appreciable amounts of lime concretions in the profile prevailed around the « Mena» ancient ruins, and hence the term « Mena» was given to them.

Soil Formation :

In discussing the soil forming processes which take place under conditions that prevail in the area, it is helpful to present the views of different pedologists who have participated in classifying the soil-forming processes of the broad zonal types.

Joffe (5) in his book on pedology states that from the point of view of pedogenesis, the classification of the soilforming processes, in their broad aspects, should hinge to the elements of climate; soils develop certain typical zonal characteristics because of the climatic conditions in the peculiar zone. This view is particularly important in the coastal belt of the Mediterranean as the sea seems to exert a big influence on

the climate of its adjacent areas. In discussing the desert-semi-desert type of soil formation, the same author stated that rainfall deficiency and hence low percolation are the most characteristic features of the process of soil formation. This climatic condition prevails over vast stretches of the Sahara and Tripoli-Libyan deserts in north Africa.

Russel (6) writes that « Chestnut soils are formed under conditions where potential transpiration exceeds rainfall, so at no time in the year does water leach out of the profile. The effect of the increasing lack of water is to give a grass vegetation with a shorter root system and a smaller annual production of organic matter. At the same time, the layer in which the calcium carbonate and gypsum are deposited come closer to the surface. As the climate becomes still more arid, shrubs begin to form an important part of the vegetation, but the production of the organic matter both above and below the ground becomes small so that the organic matter content of the soil rapidly decreases, and what is there becomes increasingly concentrated in the superficial layers. The colour of the soil also lightens, becoming first brown and then grey, giving the « sierozem» or grey desert soils of the Russians».

« The effect of increasing temperature on the grassland soils is threefold. In the first place, the colour of the soil reddens, and this is true for the prairie, chernozems and chestnut soils. In the second place, the horizon of calcium carbonate deposition may both thicken and harden, becoming a band up to several feet thick. This is known as « caliche» in parts of America, « Kankar» in parts of India, and is also well seen in many parts of the Mediterranean. If those desert soils are over-grazed, so erosion takes place, those boards become exposed on the surface of the desert, giving a hard pavement. In the third place, the organic matter decreases, presumably because of high temperature, giving a high rate of decomposition.»

In Jenny's (4) description of the soil groups that are often considered to be «climatic soil types», or zonal soils, he included the following.

Desert soils : those in which physical weathering predominates. They are very low in organic matter, and neutral or alkaline in reaction. They include the red desert soils and the gray desert soils (sierozems).

Arid-brown soils : bordering deserts and semi-deserts, light brown colour, low in organic matter, and mostly calcareous.

In discussing the desert type of soil formation, Nikiforoff (Joffe page 229), brings out the point that the principal types of soil formation which correspond to the three principle types of vegetation may be designated as a woodland type, a grassland type, and shrubland type. The last one is the desert type.

The classification system of Vilenskii (Joffe p. 178) is based on the climatic conditions of soil formation. According to the location of the soils with respect to the principal temperature zones and humidity regions, they are classified as shown in the following table.

climatic conditions of soil formation	humidity regions		soiltypes	
temperature zones	zonality	soil divisions	arid	semi-arid
polar..........	zonal	hydrogenic	tundra	semi-bog
cold	»	phytohydrogenic	sward	—
temperate	»	phytogenic	gray	chestnutbrown
sub-tropic......	»	thermophyto-genic	—	yellow soils of arid steppe
tropic..........	»	thermogenic	red soils of semi-deserts	
temperate......	»	halogenic	dry salines	red soils columnar alkali soils

From the afore-mentioned discussions, and considering the climatic conditions in the Mediterranean coastal belt of Egypt, and the field examination of various soil profiles, it may be concluded that soils of this area belong to the yellow soils of arid steppe near the coast and change gradually to gray soils, sierozems, as we proceed inland.

In general, these soils are highly calcareous, light brown in colour, and medium to fine in surface texture. The variations in profile characteristics are due mainly to the amount of precipitation which they receive, and to the micro-relief. These factors are responsible for the depth of the profile, the depth to the carbonate accumulation zone, the presence of lime concretions, the formation of hard pans, and the presence of calcium sulphate layers at the base of the carbonate accumulation layers.

Soil classification in this report is based mainly on the physical features of the various profiles with regards to the aforementioned characteristics which will be referred to, again, in discussing the different series. It is necessary to mention here that the analysis of soil samples showed some variation in the results within each series. These variations occured mainly in the texture and salt content and must be taken into consideration, in the future, when identifying the soil types and phases. Two main features, however, are discussed briefly in the following, namely; the carbonate accumulation zone, and the lime concretions. Both of them were considered in differentiating the soil series.

« The reason for the accumulation of calcium carbonate in the B horizon is as follows ! presumably this material accumulates in that part of the soil which marks the average depth of penetration of moisture. This penetration varies with the time of the year and also with the heaviness of the rainfall, so that the carbonate accumulation does not take place at exactly the same depth, even in the same soil. This accumulation takes place by two processes; one is that the mere transfer of carbonates which were formerly higher up in the soil, through solution from this higher position downward to its present position. This carbonate was made soluble in the rain-waters through the presence of carbonic acid. It was dissolved by the percolating water and carried downward to the point where the water ceased its penetration and there deposited. This is the process which takes place in soils that are developing from rocks or soil materials, whether they be consolidated rocks or unconsolidated, which contain calcium carbonates. There is, however, in the process of soil making a certain amount of « manufacture» of calcium carbonate. Calcium in rocks may exist in the form of silicate, such as is present in the feldspars or in the ferro-magnesium minerals, or in some of the other minerals. During the progress of soil development these minerals are decomposed, the calcium is released from its former combination, becomes carbonated into carbonate, and then becomes subjected to the same influence as the carbonate which was originally present in the parent rock.»

The presence of lime concretions is also a feature of some of these soils. According to the soil Survey Manual of the U. S. D. A. (8), the concretions are hardened local concentrations of certain chemical compounds that form the indurated grains or nodules of various sizes, shapes, and colours. They are commonly formed from local accumulations of calcite, iron, and manganese oxides. Other minerals such as bauxite, will readily form concretions but are not common in soils.

« The formation of lime concretions in soils is not perfectly understood, and care must be used in drawing conclusions from their presence since they presumably form when ground water becomes supersaturated. They have often been considered characteristic of soils developed from calcareous parent materials under sub-humid or arid climate. It must be recalled that they may be forming now, under the present process of weathering and soil formation, or they may simply be inherited from the parent material formed under other conditions. Loess is a parent material which frequently contains lime concretions. »

DESCRIPTION OF SOILS

1. « *Karm* » *Series.*

The representative profile is deep, fairly uniform, and contains neither carbonate accumulation zone, nor hard lime concretions. The surface soil is light brown in colour, medium to medium-heavy in texture, and is very friable when under cultivation. The soil changes gradually downward as it gets slightly compact although not necessarily heavier in texture. It is generally found in local depressions, and inside Karms where water and soil material collect after rain, making conditions optimum for barley which is the only crop grown in the area.

The physical and chemical properties of this series are favourable, and with little good management practices it can support very good growth of many crops. The continuous farming of the soil (during the winter months), and the extracting of barley stalks by hand during harvest, tend to keep the organic matter content at a very low level.

2. « *Amereya* » *Series.*

The soils of this series are featured by the presence of a definite carbonate accumulation layer in the root zone. Its depth varies, but it is generally found at about 60 or 70 cms. from the surface. These soils occupy fairly flat or gently sloping areas, and are usually associated with « Karm » series. The general description of a representative profile is as follows :

0- 60 A medium textured, friable, and light brown top soil. The thickness of this layer varies between 50 and 80 cms. in different profiles due to the succeptability of the location to erosion. The surface layer, 10-15 cms. thick, is quite hard when dry especially when not under cultivation.

60- 80 cms. Zone of maximum carbonate accumulation. It is very compact and rich in calcium carbonate which gives the soil a whitish colour. The carbonate is found as white soft concretions which decrease in amount with depth, and are generally not very conspicuous in the bottom layers. Hard lime nodules are not present, and this fact differentiates the « Amereya » series from « Mena » series which will be described later.

80-120 cms. This layer is brownish in colour and medium-heavy in texture. It contains less carbonate concretions, no pebbles (nodules), and is softer than the middle layer. The depth of this layer varies according to location and the micro-relief. It is followed, sometimes, by a coarse-textured layer before it reaches the bedrock.

Field observations indicate that the barley growth is excellent on these soils and, under normal conditions, it may be concluded that deep rooted crops can also grow fairly well. It was also noticed that although the carbonate accumulation layer is very hard when dry, yet when rain water penetrates through it, becomes soft and friable.

Utmos care must be taken in levellying of these soils, otherwise this process will bring the accumulation zone to the surface or close to it, making the seedbed unfavourable. Therefore, contour ploughing must be considered in farming the sloping areas where levelling is not advisable.

3. *« Mena» Series.*

This soil series is dominant in the Abu-Mena area, although it is also found in other parts of the project area as well. It occupies higher, fairly flat areas. The main feature which differentiates it from the two aforementioned series is the presence of cilicious nodules high in carbonates. These nodules are distributed throughout the profile but increase in number and size with depth. A general description of a typical profile is as follows :

0- 35 cms. Light brown, friable top soil which is coarse to medium-coarse in texture, and contains few soft white carbonate concretions.

35- 65 cms. Brownish in colour and slightly finer in texture. It contains few small nodules, and is slightly compact although friable in hand.

65-100 cms. The texture is medium but the compactness is considerably higher than the above layers. The presence of hard concretions is conspicuous, together with white carbonate grains, and medium size caliche fragments.

100-150 cms. Very hard substrata, rich in carbonates and gypsum, and contains many gravel-size fragments.

The agricultural prospects for these soils are fairly good, especially where the profile is deep, and the caliche concretions are absent from the root zone, the following remarks should be considered, however, when farming on these soils.

a) excessive levelling may be harmful, particularly on shallow phases.

b) detailed soil survey must be undertaken in order to locate any hard-pan formations, and to plot their depth from the surface, before choosing the suitable crops.

c) any plan for using irrigation water of low quality on these soils must take into consideration that the subsoil is high in salts. With the presence of caliche hardpans, and the possibility of initiating a water-logged condition after irrigation, surface salinization may occur, in addition to the formation of more concretions or thickening of the hardpan.

d) an efficient drainage system is needed.

e) irrigation water should be added in ample amounts and more frequently in order to keep the movemount of water downward as much as possible, and decrease the effect of capillary rise, hense reducing the hazards of salting the shallow phases.

4. *« Kandara» Series.*

These are degraded « Amereya» or « Mena» soils, not as deep, and have grayish-coloured subsoil which contains hard caliche substrata rich in salts. They resemble « Mena» series in that they both contain caliche concretions in the subsoil. The concretions are bigger in this series, and the soil material is greyish in colour and coarser in texture. These soils may be considered as transition case between the « Mena» soils and the very shallow, feebly arable, « Bahig» soils which will be mentioned later in this work.

It may be reported also that the soils of this series occupy the sloping parts of comparatively higher elevations although they were surveyed in lower parts, overlain by good « Karm» or « Amereya» soils. In the latter cases, they were found to support good to medium growth of barley. On eroded phases, only scanty natural vegetation was observed. A representative profile is described in the following.

0- 10 cms. medium-textured, slightly compact, and contains lime concretions.

10- 40 cms. medium-textured, slightly compact, and contains lime concretions.

40- 80 cms. more compact, medium-textured, greyish brown in colour, and contains many lime nodules of gravel-size.

80- cms. hard, consolidated caliche pan which is coarse in texture, and greyish in colour.

The soil map shows that these soils constitute a fairly big acreage in the southern part of the project area, namely in Kandara area starting from the southern border line and extending narrowly to the north, close to the Cairo-Alexandria desert road.

The effect of the above-mentioned soil characteristics on plant growth may be shown in the following manners.

a) the high salt content in the subsoil may, under inadequate irrigation, conditions rise to the surface layers.

b) in extreme cases where hard pans are found close to the surface, the plant root development will be checked.

c) it may be necessary to grow only salt-tolerant crops.

d) these soils need ample amounts of irrigation water of fairly good quality, and efficient system for drainage.

5. « *Bahig* » *Series.*

These are shallow, eroded « Kandara » soils, with hard pan formation at about 30 cms. from the surface. This pan varies in thickness but it averages about 30 cms. thick. It is consisted of caliche formation embeded in soft, light brown to greyish brown matrix. In the few cases where digging passed through this layer, it was noticed that friable brownish soil underlies it.

These soils are common on hilly spots of higher elevations. Water erosion is mainly responsible for their shallowness. They constitute a small total area, however, and although few patches are cultivated to barley, yet from the point of view of irrigation agriculture they should be excluded.

6. « *Mariut* » *Series.*

These soils are generally found in low, flat areas around lake Mariut, and also in the depressions contained between the coastal and the second lime stone ridges close to the Mediterranean sea. In the four major areas which constitute the main body of the project, these soils were surveyed only in a small part of the Bahig area.

Their profile is characterized by a coarse textured surface layer which is yellowish brown in colour. The coarseness of this layer and thickness depend on the amount of drift sand and wash materials which deposit from the adjacent slopes. The texture gets slightly heavier below 30 cms., and the subsoil is dark grey and sticky, with few bluish mottlings below 50 centimeters. The colour of the profile gets bluish at about 80 cms. where the permanent saline water table usually fluctuates. The accumulation of salt crystals sometimes exists at this depth, and the top soil is covered by a salt crust whose extent depends upon the depth to the saline water table.

The soils of this nature are common in Krier area which is hilly and, most probably, will never benefit from any schemes for canal irrigation. Since this area receives more rain, during winter months, than the inland part of the zone, therefore the utilization of such soils for agriculture must depend on the following practices.

1. The effective conservation and use of rain waters.
2. The utilization of the limited amount of water which could be pumped out from shallow wells, by wind pumps.
3. Selection of salt tolerant crops.
4. Adopting soil conservation measures to prevent soil erosion.
5. The addition of organic manures and mineral fertilizers.

7. « *El-Kasr* » *Series.*

These soils are common on hill-sides and foot-hills of the limestone ridges which run almost parallel to the coast. They are also found in fairly level patches where wind-blown or water-carried soil material is deposited to considerable thickness.

Their profiles are open, quite deep, and contain many shell fragments. The texture of the soil ranges from coarse sand to sandy loam and its colour is light brown to yellowish brown. The coarseness of texture, especially of the top soil, is due mainly to the migration of the finer material by rain water to lower depths. This transportation of fine material renders the soil slightly heavier in texture at depths ranging form four feet or more. The profiles are shallow towards the hill-tops where the bedrock comes closer to the surface due to water erosion.

It may be stated that the physical properties of these soils are optimum for plant growth. Many orchard trees such as figs, olives, almonds, and grapes are grown successfully at Burg El-Arab farm, and at El-Kasr area west of Mersa Matruh. Water-melons, tomatoes, onions, cucumbers, and few other vegetables give high yields on the low amount of rain-water which the soil can store during the rainy season.

For the adequate utilization of these soils, good soil conservation practices must be adopted, such as water spreading, terracing, and contour furrowing, in order to prevent soil erosion and conserve rain water. Low, closely spaced, ridges must be constructed in order to slow down the runoff water and give it time to percolate downward. It must be emphasized also that any management practice for the cultivation on slopes should avoid the destruction of the natural vegetation cover. This cover not only holds the soil in place, but it also enhanses water penetration into the soil where it is stored.

8. « *Agamee* » *Series.*

These are composed of almost pure whitish oolitic limestone grains, in loose or semi-consolidated dunes. They constitute only a minor part of the soils in the coastal strip, mainly on the first ridge by the Mediterranean sea.

Fig trees, in particular, seem to be adopted to such soil conditions as they grow successfully with very little management efforts, especially during the first two years of planting. Therefore, their plantings should expand to cover all areas where these soils are found.

DESCRIPTION OF AREAS

1. *Kandara Area.*

This area occupies the southeastern part of the project, and is included in the topographic map No 90/495 scale 1:25.000, between kms 495 to 510 east of origin, and kms 900 to 910 north of origin. All of it

was investigated during this work, except for an area of about 1750 feddans east of the Cairo-Alexandria paved road.

Contour lines indicate that the surface elevation varies between 15 and 50 meters above sea-level. However, these differences in elevation are comparatively less conspicuous than in Abu-Mena or Bahig areas. The surface topography shows a gentle slope from Alam Shaltoot and Ilwet El-Gireisat in the south and southwest respectively, down to the north and northeast parts where few old « Karms » are located. These karms are old man-made dykes which were constructed to collect and conserve rain water for agricultural and civic purposes. This is indicated by the presence of cisterns and small surface reservoirs for water around them. The soils inside these enclosures are deep and uniform though fine textured, and support very good growth of barley, making them centres for bedouin small settlements. Some of these karms are; Kandara, El-Efrit, El-Oni, Abu Dodash, Shagana, El-Tifla, and El-Khineig.

The surveyed area is approximately 142 square kilometers (about 34000 feddans). Field examination included testing a number of 129 profiles which were dug to depths of about 120 cms. The sites of these profile pits were chosen in such a way that they represent all contour levels and, in the meantime, reveal any soil profile variations. Accordingly, the spacings between pits varied around one kilometer distances.

Profiles in the southern part showed the presence of grey, hard, coarse-textured, and gritty layer with apparent salt crystals.

This layer is only 20 cms. From the surface in profile 6A, but it gets deeper towards the north and northwest (at 90 cms. in profile no. 9A, at 80 cms. in profile no. 1A, and at about 70 cms in profile, no. 12A). All soils of this nature belong to «Kandara» series which was described earlier in this report.

It may be morersafe, therefore, to exclude the southern part of the area, at least in the initial stages, and consider the boundary of the project from the south at about kilometer 172 (distance from Cairo).

Four major soil series namely; Karm, Amereya, Mena, and Kandara, are represented by big areas. The following table shows the distribution of these series with regards to the contour levels.

Soil Series	Areas, in feddans, of soil series at different contours							
	10-15 mtr.	15-20 mtr.	20-25 mtr.	25-30 mtr.	30-35 mtr.	35-40 mtr.	above 40 mtr.	total feddans
Karm........	450	750	2050	650	100	—	—	4000
Amereya.....	—	400	4200	2900	500	—	—	8000
Mena.......	—	—	1650	4950	3500	1750	1350	13000
Kandara.....	50	2200	2300	300	1000	800	1850	9000
Bahig.......	—	—	—	—	50	—	—	50
Unsurveyed...	—	—	—	—	—	—	—	1750
Total...	500	3350	10200	9300	5150	2550	3200	36000

2. *Amereya Area.*

This area lies north of area I, and is included in the topographic map no. 91/495; scale 1:25.000. The study of soils covered only that part of it west of the Cairo-Alexandria desert road, and approximates 21.000 feddans. A number of 80 pits were examined.

The general features of the area are described briefly as follows :

1. Surface elevation varies between 10 and 40 meters above sea-level and, therefore, it is generally lower in elevation than the area in the south.

2. Differences in elevation between various locations are comparatively small.

3. The highest point is about 46 meters on Elwet El-Qurein the north-western corner of the area.

4. The general slope runs from the south and west down to the north and east.

5. A number of 15 major karms and few little ones are distributed in the area. Some of these karms are; Kandara, El-Qureyed, El-Humeyirat, Abubaail, Abu Bisissa, Fetiha, Abu Shanab, Sidi Sho'eib, El-Sihimeya, El-Delaima, Abu Kheleif, El-Hag, El-Quird, El-Sanab, El-Arawa

6. A number of about 19 wells (sanyet) and seven shallow wells (bîr) are located around these karms.

7. The soil map (figure 3) shows the distribution of the following soil series :

Karm Soil Series : It occupies an area of approximately 4000 feddans of good, uniform, and deep soils. Almost all of it lie at 25 meter contour levels or less, and most of it between contours 15 and 25 meters above sea-level. The soils of this series are found generally inside and around Karms, and their need for levelling is small.

Amereya Soil Series : Profiles of this series represent good soils with carbonate accumulation zone at 60 or 70 cms. depth. They occupy an area of approximately 8800 feddans, lying in locations of less than 25 meters above sea-level.

Mena Soil Series : It constitutes about 36000 feddans most of which are in the northern half of the areq. These soils are characterised by the presence of numerous lime concretions in the solum. Although their profiles are fairly deep, yet their physical and chemical properties indicate that they are less productive than the Karm and Amereya series.

Kandara Soil Series : The soils of these series are featured by very compact subsoil which is high in salt content. They occupy an area of about 4100 feddans distributed in the whole area particularly in its southeastern part, where the majority of the surface elevation lies under 25 meters above sea-level. In places where ground elevation is less than 20 meters, the profilesiwere found to be comparatively deep while those above 25-meters levels were not deep, and their possibilities for successful agriculture are dim.

The following table shows the distribution of the different series in this area, with respect to various contour elevations.

Soil Series	Areas, in feddans, of soil series at different contours							
	10-15 mtr.	15-20 mtr.	20-25 mtr.	25-30 mtr.	30-35 mtr.	35-40 mtr.	above 40 m	total feddans
Karm	350	3300	200	250	—	—	—	4100
Amereya	2150	3000	2500	750	350	50	—	8800
Mena	350	2100	500	500	100	50	—	3600
Kandara	650	1200	1100	650	300	150	50	4100
Bahig	—	30	45	120	60	30	15	300
Rocky	—	—	—	—	30	50	120	200
Total ...	3500	9630	4345	2270	840	330	185	21100

III. Abu-Mena Area.

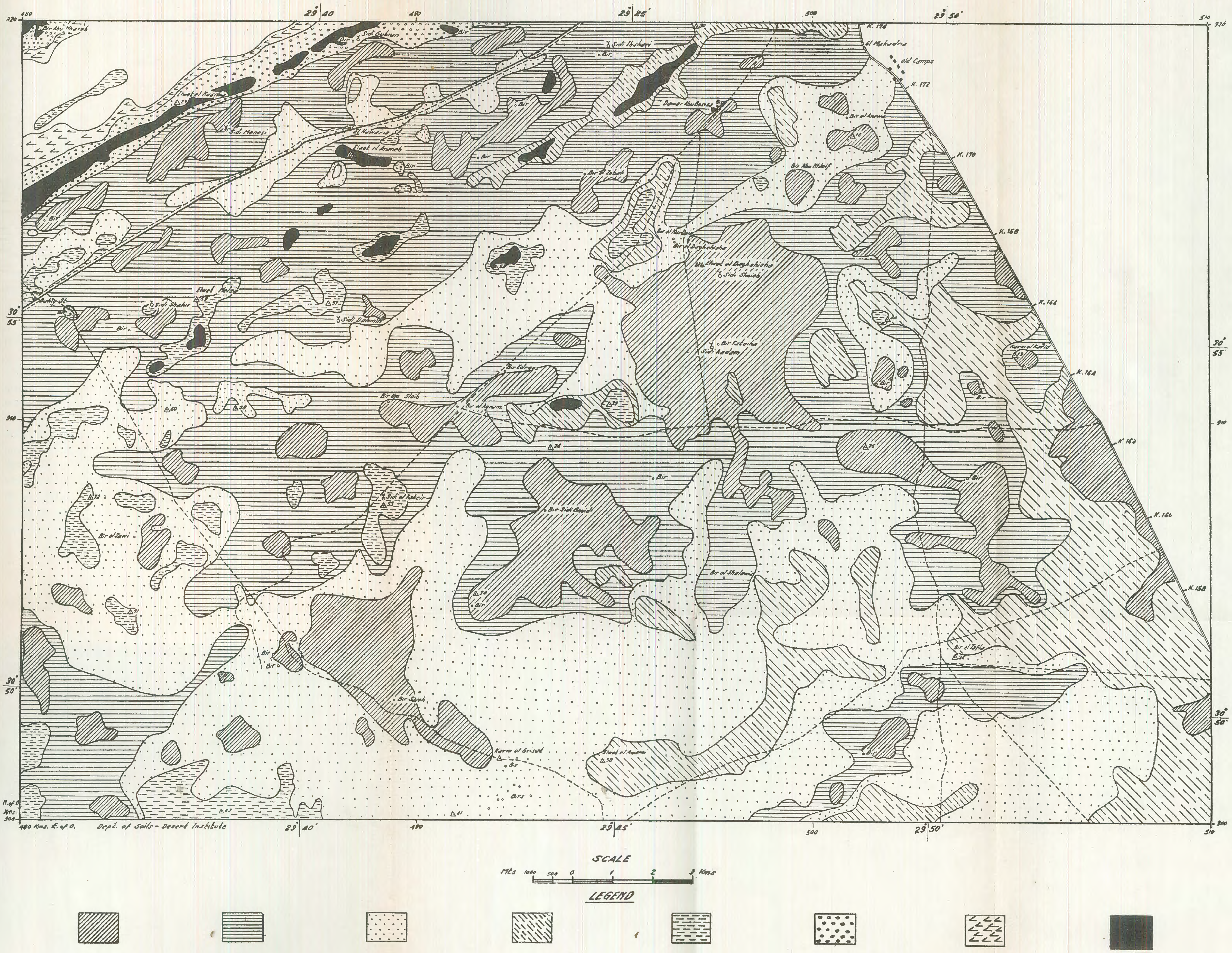
This area is included in the topographic map No 90/480, scale 1:25.000 and was all investigated during this work. Soil profiles were examined with the auger since soil moisture at the time of investigation was ample enough to allow for its use. A number of 100 test bores were tested and according to the properties of the soils they were related to those which were previously surveyed in the first also two areas. The type of survey which was conducted in this area and in the Bahig area is more of a semi-detailed reconnaissance nature.

The surface elevation varies between 25 and 60 meters above sea-level, and the differences in elevation are somewhat big, especially in the western part, giving undulating topography. It is generally higher in the west and south, and slopes down to the east and north. The area is also featured by the presence of few hilly spots (Elwat) some of which are called : Awamee, Showelhi, Abu Barseem, Gowera Abu-Shadda, Ibeida, Gabal Abu Hamda, Elwit Abbas, El-Mossni Lamloum, and others.

These high spots enclose a number of karms, namely; Shagana, Tayel Moussa, Sibeiq, Ehbareya, Agram, Masaney, Goera, Abbas, Moelhy, Bassil, Abu El-Gurouf, Saqqara, Shoelhi, and others.

A number of approximately 70 cisterns are scattered in the area, but most of them are grouped around El-Greissat in the south-eastern

MAP SHOWING DISTRIBUTION OF THE DIFFERENT SOILS SERIES IN THE SURVEYED AREA OF MARIUT PROJECT



KARM SERIES — DEEP PROFILE WITH NEITHER CARBONATE ACCUMULATION ZONE NOR LIME CONCRETIONS.

AMEREYA SERIES — DEEP PROFILE WITH VERY LITTLE OR NO LIME CONCRETIONS, BUT A DEFINITE CARBONATE ACCUMULATION ZONE AT 60 OR 70 CMS. DEPTH.

MENA SERIES — DEEP PROFILE WITH NUMEROUS HARD LIME CONCRETIONS THROUGHOUT THE PROFILE AND NOT SO-DEFINITE CARBONATE ACCUMULATION ZONE.

KANDARA SERIES — DEGRADED AMEREYA OR MENA SOILES NOT AS DEEP GREYISH SUB-SOIL WITH BIG HARD CALICHE CONCRETIONS RICH IN SALTS.

BAHIG SERIES — VERY SHALLOW SOILS WITH GRAVELS ON TOP AND CALICHE SOLID PAN CLOSE TO SURFACE.

EL-KASR SERIES — VERY DEEP, LOOSE, COARSE-TEXTURED, LIGHT BROWN SOIL WITH SHELL FRAGMENTS, AND NO PROFILE DEVELOPMENT.

MARIUT SERIES — SALINE COARSE-TEXTURED LIGHT BROWN SURFACE SOIL, AND STICKY BLUISH GREY SUBSOIL. WATER-TABLE AT ABOUT EIGHTY CMS.

ROCKY — MATURE LIMESTONE ROCK, CONSOLIDATED OR FRAGMENTED, ERODED AND BARREN.

Fig. 3

corner, and in the karm area near the old ruins of Abu-Mena temple. Water points include also about eight surface reservoirs and three wells.

It may be stated that the area includes appreciable Patches of good and fairly good soils. The distribution of the different soil series is shown in the attached soils map, and the individual areas each series are presented in the following table :

Soil Series	approximate areas, in feddans, at different contours							
	10-15 mtr.	15-20 mtr.	20-25 mtr.	25-30 mtr.	30-35 mtr.	35-40 mtr.	above 40 m.	total feddans
Karm........	—	—	400	1300	1800	1000	1300	5800
Amereya	—	—	150	1500	200	400	6350	8600
Mena	—	—	—	2100	1900	6600	8200	18800
Kandara	—	—	—	50	150	50	150	400
Bahig	—	—	—	—	—	450	1950	2400
Total ...	—	—	550	4950	4050	8500	17950	36000

It is clear from this table that the Mena soil series prevail in this area, especially where ground-surface elevation exceeds 35 meters above sea-level.

IV. Bahig Area.

The current investigation covered all the area included in the topographic map No. 91/480, scale 1:25.000. A number of 109 boreswere tested by the auger at distances averaging about 1.25 kilometers. The soils were classified according to their profile characteristics into the different series corresponding to similar ones in the other three major areas. Its contour map shows that the ground elevations are comparatively higher than in the rest of the project area, except in the north-western corner where the elevation becomes zero in the dry salt marsh of lake Mariut. Most of the area is encountered between the 30 and 70 meter contour lines, and the general slope of the ground surface runs from south down to the north.

This area is featured by the existence of many rocky hills (Elwat), the most conspicuous of which are; Gabal El-Quarn in the south-east, and the hills which from the limestone ridge parallel to lake Mariut and south of it.

A big number of small karms are distributed in the area, enclosing good, productive « Karm» soil series. The soil series was also surveyed in the many local depressions which are located between the hilly parts in the middle portion of the area.

Other than the five series which were found in the previously mentioned areas, the following two soil series were also identified;

El-Kasr Series : very deep, loose, coarse-textured, light-brown soil with shell fragments, and no profile development. It is generally found on slopes and at the foot-hills of the northern limestone ridge.

Mariut Series : saline, coarse-textured, light-brown surface soil, and sticky bluish subsoil. The water table exists at about 80 cms. from the surface.

The following table shows the distribution of the various soil series at different contour levels, in this particular area.

Soil Series	areas, in feddans									
	0-5 mtr.	5-10 mtr.	10-15 mtr.	15-20 mtr.	20-25 mtr.	25-30 mtr.	30-35 mtr.	35-40 mtr.	above 40 mtr.	Total fed.
Karm.....	—	—	6600	500	400	250	650	400	200	3000
Amereya ..	—	—	2400	2500	1200	1700	3500	2300	4700	8300
Mena	—	—	250	150	400	1200	800	300	3600	6700
Bahig	—	100	50	—	50	250	150	200	700	1500
Kandara ..	—	—	—	—	—	50	150	300	200	700
Mariut....	550	150	—	—	—	—	—	—	—	700
El-Kasr...	—	600	500	250	100	250	—	—	—	1700
Rocky	—	—	20	80	—	—	50	50	900	1100
Salt Marsh	2300	—	—	—	—	—	—	—	—	2300
Total...	2850	850	3820	3480	2150	3700	5300	3550	10300	36000

The presence of more than 45 deep native wells (sawani) and about 20 underground storage cisterns (abar) indicates comparatively intensive

use of this area in the past, and the needs for good water conservation systems in the future. Die to its hilly topography, and the existence of many rocky spots, levelling for irrigation agriculture would be impractical and, therefore, the development of agriculture in this area should concentrate on contour farming, terracing, and the use of underground water.

SUMMARY

In order to classify the soils of the Mediterranean coastal zone into the system which includes the major zonal groups, the soil-forming factors are discussed, and the views of few soil pedologists are presented. Although they agree on the type of soil formation processes which take place under the temperate climate of the Mediterranean, yet they tend to classify these soils as seirozems. It was noticed, however, that the influence of the sea on the climate of the coastal strip, added to the effect of microrelief, have resulted in certain profile characteristics similar to those of the '«yellow» arid steppe' rather than « seirozem». More intensive studies may reveal that these soils belong to a new sub-group called « Mediterranean Steppic Soils». This is true only for the soils of the strip close to the sea but as the influence of the latter decreases inland the soils are reported to be of the « grey desert» or «seirozem» nature.

In general, these soils are highly calcareous, light to dark brown in colour, medium to fine in, and low in organic matter. The variation in profile characteristics are due mainly to the amount of precipitation and to the effect of microrelief which is responsible for the extent of leaching, deposition, and erosion precesses.

The soil surveying consisted of examining a number of 418 pits and test holes in an area of approximately 130000 feddans. The depth of examination was about 120 cms, and the distance between profiles ranged from 500 to 1500 meters. Based on the following features, the soils were classified into eight distinct series, texture, depth (root zone), depth to the carbonate accumulation layer, presence of gypseous layer at the base of the carbonate zone salinity, and lime nodules.

The eight soil series are given local names, and their distribution is shown on the soils map. These series are :

1. *KARM Series :* deep profile, with neither carbonate accumulation zone nor lime concretions. The soils are medium to fine-textured, and brownish in colour.

2. *AMEREYA Series :* deep profile, with very little or no lime concretions, but contains a definite carbonate accumulation zone at 60 or 70 cms depth.

3. *MENA Series :* fairly deep profile, with numerous hard lime concretion distributed throughout the profile, and a not-so-definite carbonate accumulation layer.

4. *EL-KASR Series :* very deep, loose, coarse-textured, light-brown soil, with shell fragments and very little profile development.

5. *KANDARA Series :* degraded Amereya or Mena soils, not as deep and with a greyish subsoil which contains big, hard caliche fragments rich in salts.

6. *BAHIG Series :* very shallow soils with few gravels on surface, and caliche solid pan close to the surface.

7. *MARIUT Series :* saline, coarse-textured, light brown surface soil overlying sticky, bluish grey subsoil. The saline water-table fluctuates around 80 cms from the surface.

8. *AGAME Series :* almost pure, whitish oolitic limestone grains in loose or semi-consolidated dunes.

The profiles of these different series are described in detail, along with notes on their proper management, and precautions to be considered before executing any reclamation projects for them. These soils would fit in the tentative land capability classification as follows :

Class I : nearly level, deep, permeable soil, suitable for irrigation, agriculture with no special limitations. It is represented by « Karm» series which covers an area of approximately 18700 feddans.

Class II : not as level, moderately deep, fairly, permeable, soils suitable for cultivation with minor limitations. It is represented by two soil

series. Amereya and Mena in about 40.000 and 42.000 feddans respectively.

Class III : deep to moderately deep soils, suitable for agriculture but having major limitations; stonisess, texture or erosion hazards. It is represented by the « El-Kasr» series in about 1700 feddans.

Class IV : fairly poor land. Its safe cropping-use is limited by its, inferior profile characteristics such as, saline subsoil or compact caliche formations, or shallowness. It is represented by « Kandara» and « Mariut» series with areas approximating 4000 and 700 feddans respectively.

Class V : shallow, moderately sloping lands, suitable for occasional agriculture only. It is represented by « Bahig» series in an area of about 4000 feddans, and « Agamee» series which is not found in the project area.

Class VI : rocky.

Results of The Chemical Analysis of Soil Samples

Series	prof. no.	depth	CaCO	mech. composition gms. 100 gms.			PH pasto	organic carbon	E.G/10 saturated extract
				sand	silt	clay			
Karm........	13-A	0-120	29.8	53.1	3.9	5.7	7.80	0.18	1.50
Amereya	21-A	0-45	34.9	36.8	10.8	8.6	7.90	0.33	1.60
		45-85	38.9	37.6	9.8	7.6	7.85	0.17	5.50
		85-120	17.4	57.9	14.8	2.5	7.65	0.11	6.00
Mena	10	0-20	40.9	33.0	11.5	10.6	8.00	0.30	11.00
		20-40	33.5	31.0	6.9	11.2	7.97	0.20	19.00
		40-80	41.2	40.2	6.3	9.2	7.97	0.15	17.00
	28	0-15	31.3	44.7	10.3	8.1	7.80	0.39	2.60
		15-120	39.6	33.0	8.5	11.6	7.87	0.23	3.00
Kandara	6-A	0-20	17.40	—	—	—	7.59	0.15	2.80
		20-120	23.00	—	—	—	8.05	0.11	2.80
	9-A	0-45	32.8	43.5	8.2	6.9	8.14	0.17	9.50
		45-80	33.1	38.5	10.1	9.3	7.95	0.13	27.00
		80-120	33.9	47.2	9.0	10.3	7.92	0.13	22.00
	41-A	0-30	38.3	—	—	—	7.70	0.31	12.00
		30-50	35.9	—	—	—	7.62	0.23	28.00
		50-120	11.5	—	—	—	7.65	0.10	28.00

Analysis of 1 : 5 soil-water Extract

Series	profile no.	depth cms.	T. S. S.	concentrations of ions. m. e. /100 gms. soil						
				CO_3	HCO_3	C_l	SO_4	C_a	M_g	N_a+K
Karm....	13-A	0-120	0.20	nil	0.5	0.6	2.3	0.5	0.8	2.1
Amereya .	21-A	0-45	0.37	»	0.5	2.3	4.8	0.5	0.8	6.3
		45-85	0.24	»	0.5	0.6	2.7	0.5	0.8	2.5
		85-120	1.48	»	0.2	0.8	18.7	12.5	2.5	6.7
Mena ...	10	0-20	0.33	»	0.5	3.7	1.5	1.0	tr.	4.7
		20-40	0.66	»	0.5	8.5	1.7	1.5	»	10.2
		40-80	0.67	»	0.5	9.0	1.0	1.5	»	9.0
	28	0-15	0.08	»	0.7	0.3	0.4	0.5	»	0.9
		15-120	0.14	tr.	0.7	0.8	0.4	0.5	»	1.4
Kandara .	6-A	0-20	1.07	nil	0.3	0.3	15.6	3.5	0.8	11.9
		20-120	1.54	»	0.2	9.3	7.1	10.0	3.3	3.3
	9-A	0-45	0.28	»	1.0	2.5	0.5	1.0	tr.	3.1
		45-200	0.99	nil	0.5	13.0	2.3	1.5	1.6	12.7
		80-120	0.77	nil	0.5	9.9	2.5	1.0	1.6	10.3
	41-A	0-30	0.79	nil	0.5	10.7	0.8	2.5	1.6	7.9
		30-50	2.10	»	0.5	25.7	9.4	9.6	4.9	21.1
		50-120	1.63	»	0.2	5.6	18.9	18.0	3.3	3.4

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REMARKS ON THE AGE AND ORIGIN OF GROUND WATER IN THE WESTERN DESERT WITH SPECIAL REFERENCE TO EL KHARGA OASIS

(SOUTHERN PROVINCE, EGYPT, U. A. R.)

BY

RIAD A. HIGAZY AND A. SHATA

INTRODUCTION

There are different schools of thought concerning the source of the underground water in the Western Desert of Egypt. The various points of view can be summarized as follows :

1) According to Beadnell (1908 and 1909), Lyons (1908), Graham (1910), Fox (1949), Mitwalli (1951) and Shata (1959) the Nile Basin is considered as the main source of water infiltrating the « Nubian Sandstone Series » of the Western Desert. Some of these authors, namely Beadnell (1908 and 1909) and Lyons (1908) considered the Sudan rains as another possible source.

2) Hume (1925) and Sabri (1957) mentioned that the Sudan rains are the main origin of the underground water in the Western Desert. Moreover, Sabri (1959) stated that possible augmentation of this water could be attributed to the Nile Basin.

3) Ball (1927), Sandford (1935), Hellestrom (1940) and Ezzat (1959) regarded the « highlands » of the French Equatorial Region, and in particular the parts situated at Erdi and Ennedi, as the main possible sources of water in the Western Desert.

4) Pavlov (1960) drew the attention to the fact that the amount of water stored in the «Nubian Layers», below El Kharga District, was mainly formed during one interval, or more, of the Pluvial period. Mr. Pavlov added that this stored water is recharged by small quantities from a variety of sources. These include the rain at Ennedi, Erdi, North Abbysinia, Eretria and the southern portion of the Nile Basin; the Nile water and eventually the occasional showers.

5) M. Ibrahim (1960) in his lecture to the Geological Society of Egypt raised the question of the relationship between the « Regional Arch» and the artesian water supplies of Egypt. To him the regional structure as well as the rain of the highland mass of Abbysinia, are the main factors controlling the ground water supply of the «Nubian Layers».

DISCUSSION

At El Kharga Oasis (Fig. 1) the strata of hydrologic significance are the « Nubian Sandstone Series». These sandstones are widely distributed in space as well as in time. They cover an immense area in the southern part of Egypt and differ in age from Early Palaeozoic to late Mesozoic.

El Shazli, Shata and Farag (1959) dealing with the subsurface geology of El Kharga Oasis mentioned that the « Nubian Type» sandstones have a thickness of about 1400 m and are distinguished into three main groups (Fig. 2). From top to base, these groups are as follows :

1) Late Mesozoic sandstones and clays (Upper Cretaceous); with a maximum thickness of 442 m.

2) Palaeozoic-Mesozoic sandstones, conglomerates and clays; with a maximum thickness of 775 m.

3) Palaeozoic sandstones; with a maximum thickness of 200 m. (These sandstones overlie directly the « Basement Rocks».)

In the new deep wells, drilled at El Kharga, water logged sandstones have been reported in the three groups mentioned above. These groups occur at various depths in the different wells.

Taking into consideration the nature of the stratigraphic sequence at El Kharga and the type of the local and regional structure, the authors

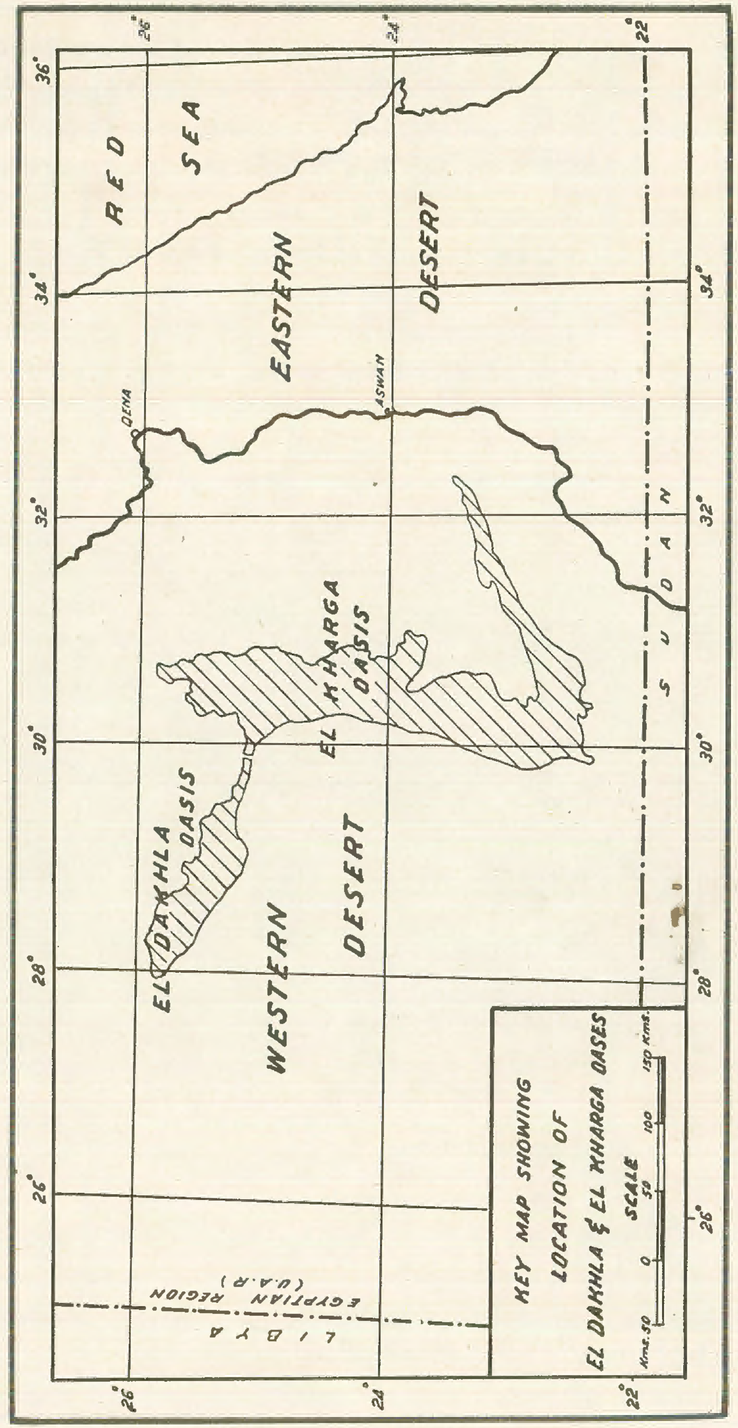

Fig. 1

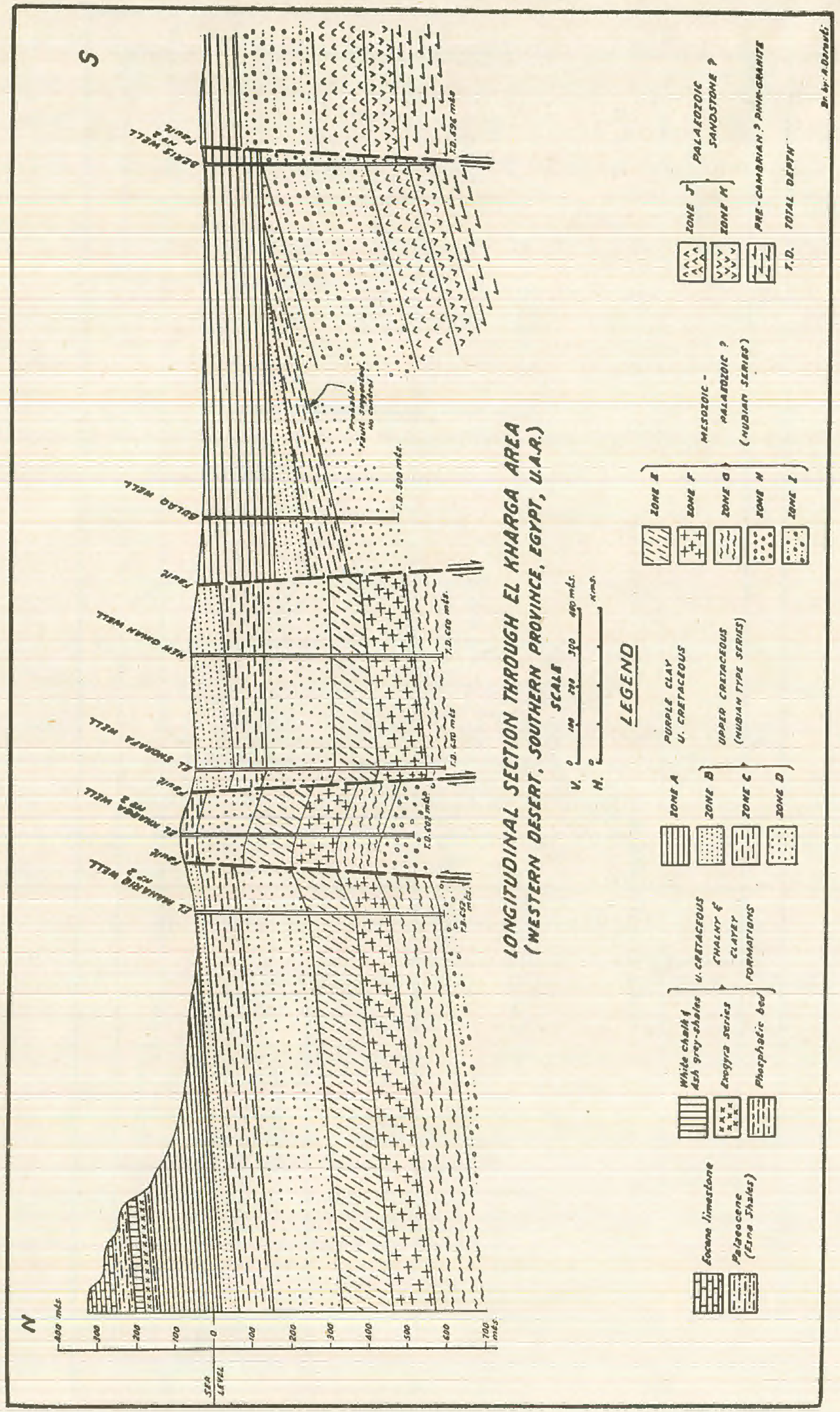

Fig. 2

are inclined to believe that the water of the lower-most beds (group III which is represented in Beris well No. 2) is « Recent» and is, therefore, considered as renewable water, since its source is the rain which falls annually on the countries to the south of Egypt, namely on the Sudan as well as on Abbysinia. The water in the upper beds, i. e. group II which is represented at El Kharga and El Maharik, and group I which is found in Bulaq could be of two main sources differing in age. The water reported in the strata of « Group II», is in the authors' opinion « young renewable» water similar to that found in the lowermost beds (group III) with additions from the relatively « old and non-renewable water» formed during the Pluvial Periods when the Western Desert was of high rainfall

Photo 1. Complicated drainage pattern dissecting the plateau surface and the escarpment in the vicinity of El Kharga; air view (Photo, by A. Shata).

as well as torrents. This is evidenced by 1) the hydrographic pattern and erosional channels which dissect the plateau down to the depression floor (Photos No. 1 and 2), 2) the presence of «calcareous tufa» in some of these channels (Caton-Thompson and Gardner, 1932) and 3) the presence of terraces occurring at different heights above the depression floor

(Ball, 1900; Beadnell, 1909; Caton-Thompson and Gardner, 1932; Sandford and Arkell, 1935) formed of pebbles, cobbles and boulders of different sizes reaching in places 60 cm in diameter (Photo No. 3). The water present in the uppermost strata (Group I) is similarily of two main sources but the major part is Pluvial and the minor part is «Young renewable» (Fig. 3).

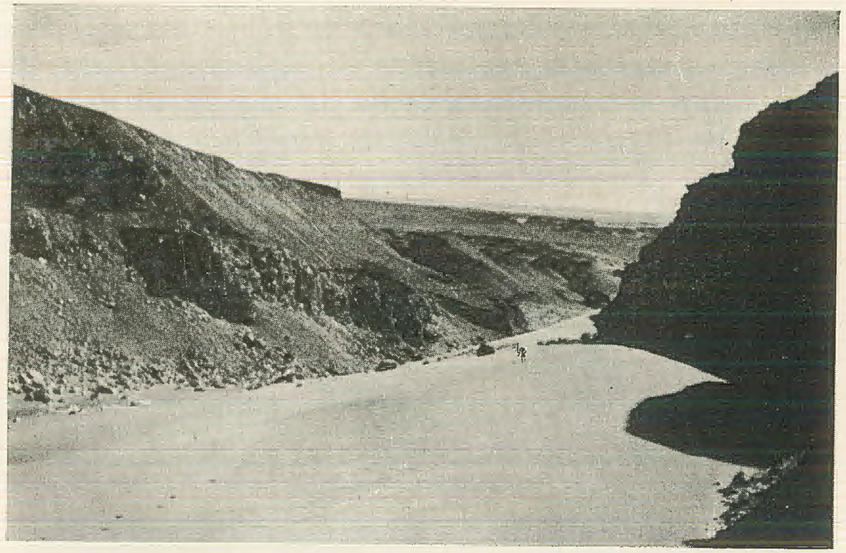

PHOTO 2. An old drainage channel dissecting the northern escarpment in El Dakhla Oases; this channel is filled with drift sand and is bounded by gravel and boulder terraces; view looking south (Photo by A. SHATA).

On structural basis, El Kharga Area constitutes a portion of the «foreland overlap» on the «Stable Arabo-Nubian Shield Mass». In the southern portion of El Kharga, the shield rocks are either exposed (Abu Baiyan, 40 Km. to the south of Beris Village) or occur at shallow depth below the surface (in Beris Well No. 2, the shield rocks are reported at a depth of about 600 m below the surface). These dip regionally in a northward direction at an angle less than 1°; and are overlain by the oldest Nubian Series of Palaeozoic age (Beris Well No. 2). We expect the same series to extend southwards from Beris i. e. up dip or up-structure, and may crop out in the southern parts of Egypt (similar beds are described by

Sandford at El-Eweinat, 1935) as well as farther south in the Sudan, the French Equatorial Africa and other equatorial regions. In these countries the rate of rainfall is very large reaching over one metre annually (Hurst, 1944). A great proportion of this water percolates through the porous «Nubian Type» layers and moves essentially down dip i. e. in a northward direction where it become stored in such layers belonging

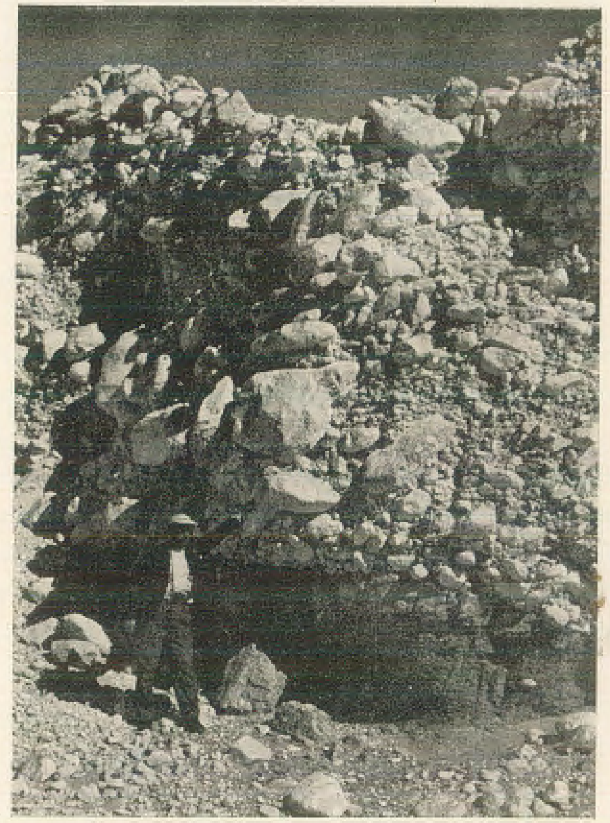

PHOTO 3. Young Wadi Terraces in El Dakhla Oasis; boulders mainly subrounded (Photo by M. SABRY).

to «group III» which are reported in Beris Well No. 1 at a depth of about 400 m from the surface. In Bulaq Well No. 1, located 45 km to the North of Beris Well, these layers were not found at a depth of 500 m from the surface and are not expected befor 800 m. Also at El Kharga,

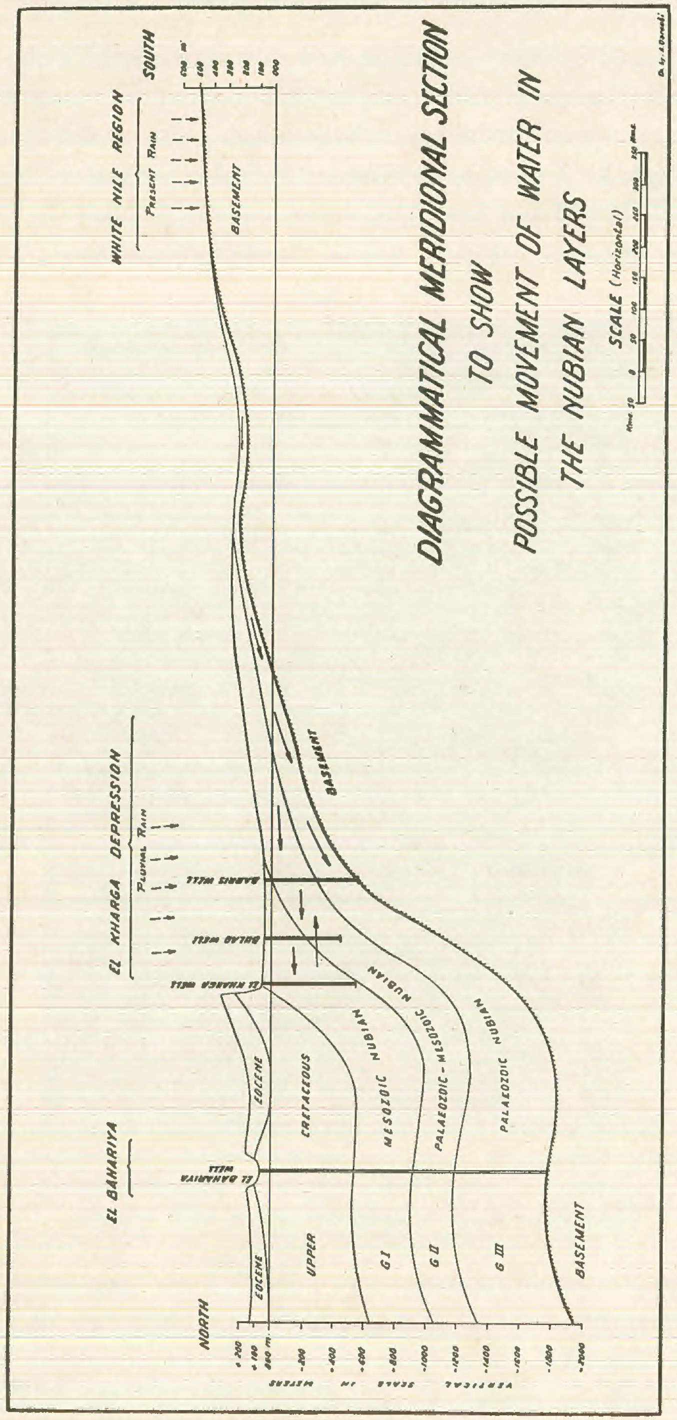

Fig. 3

such layers do not exist at a depth of 650 m from the surface. All this confirms the view that the prolific layers of Beris Well No. 2, which hold the «young renewable water» have not been found in the other deep bores of El Kharga and may thus be expected at greater depths. Other types of water are found in the overlying strata, i. e. groups II and I (Fig. 3).

CONCLUSIONS

The subsurface geology of El Kharga (El Shazli, Shata and Farag 1959) shows that we have three types of water : —

1) Renewable water preserved in the lowermost formations overlying the basement rocks (Group III) and is regarded to be of very recent age. It is renewable water and the rains of the equatorial countries to the south of Egypt are its source.

2) Pluvial water which is not renewable and can be found in the uppermost formations (Group I).

3) A mixture of both these two types of water and is present in the intermediate formations (Group II).

The amount of Pluvial water is expected to show a general increase in the relatively higher horizons of the « Nubian Layers» whereas the recent water increases in the relatively deeper horizons. These assumptions should be considered as tentative until the ages of these waters are determined and hence much light will be thrown on this matter.

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LAKE MOERIS AND LAHÛN
MI-WER AND RO-HÛN

THE GREAT NILE CONTROL PROJECT EXECUTED BY THE ANCIENT EGYPTIANS

BY

ALI SHAFEI

1. *Preface :*

The subject of this paper has been published in detail in Arabic by the Ministry of Public Works, in 1957 [1]. Only 225 copies have been printed but since the work included many new additions to previous studies ; such as the drawing to scale of the Lahûn weir, it was thought fit to give it a wider circulation. The weir was described by two Arab writers of proved integrity and sound reasonning as will be shown in the text.

Since the beginning of the last century when Egypt started cultivating cotton, and the need for storage of water to increase the summer water supply was apparent, numerous books have been written on Lake Moeris.

Some writers stated that the reservoir existed only in the imagination of Herodotus whom they said was mislead by dragomen. To mention some of them I give Fourteau 1895 (25) and Caton Thompson 1934 (3). The doubt on the existence of this reservoir was dispelled by other writers as André Pochan 1935 (26) and O. H. Little 1936 (4).

The writers on the subject who believed in a Moeris Reservoir in Ancient Egyptian times differed among themselves as to its site. Linant de Bellefonds put it in the higher part of the Fayoum, together with the Arsinoite nome which extended between it and the present lake Qarûn. Other writers put it so that all Ancient Egyptian towns were above its level and that is the correct idea.

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[1] بحيرة موريس واللاهون – مى ور واللاهون – أول عمل أقامه المصريون لضبط النيل – نشرة وزارة الاشغال سنة ١٩٥٧ .

Dams and reservoirs and irrigation projects are of the greatest importance in arid countries, and Arab engineers should be encouraged to study the achievements of their predecessors, as for example the Maäreb dam, the study of which will help solve the irrigation problems of ʿAsir and Yemen.

The study of Lake Moeris is now of no practical importance for there is no need now for the Wadi el Rayyan Project as the Sadd el ʿAli at Aswan has been sanctioned and is being constructed to impound the flood waters. This paper is only an attempt to illustrate the capability of the Ancient Egyptian engineers, who more than 5000 years ago were able to design and execute the first masonry works to control the river Nile and to provide an automatic overflow basin to guard against dangerous floods. Their object was also to ensure a high summer supply to aid navigation and help irrigate gardens and summer cultivation which was practiced as mentioned in the letter of the scribe Pibesa (32-237).

Dr. John Ball (19-222-27) stated that Nabulsi's description of these structures (The weir at Lahûn) was not very clear and indeed he could hardly have made it so without the accompaniment of a sketch plan and section.

Sir Alan Gardiner wonders at the mention of Ro-Hûn [1] without the determinative of the town ⊗ at the end of the name, as usual, but now we know that the name stands for the masonry weir and means the mouth of the canal and the name is used now in Arabic فم الخليج . This masonry mouth of the canal has persisted up to 1245 A. D. Nabulsi made a description of it, and before him Abu Isḥaq Ibn Gaāfar in 1030 A. D. gave a more elaborate description with dimensions in cubits. Fortunately one description (Nabulsi) concentrates on the heights whereas the other (Abu Isḥaq) gives the horizontal measurements [2].

(1) in Coptic : ⲗⲓϩⲱⲛⲉ — ⲗⲉϩⲱⲛⲓ.

(2) I am indebted to the authors of the books mentioned in the list of references especially the late savants Dr. John Ball, Mr. O. H. Little, Sir Flinders Petrie, Sir Hambury Brown and M. Linant de Bellefonds. To the living authors I am much indebted to Miss Caton Thompson and Miss Gardner, Kamel Osman Ghaleb, Sir Alan Gardiner and Dr. Ahmad Fakhry. My gratitude should be also expressed to Sayyid Ahmad Abdou al Sharabasi the Minister of Public Works for ordering the printing of the Arabic text.

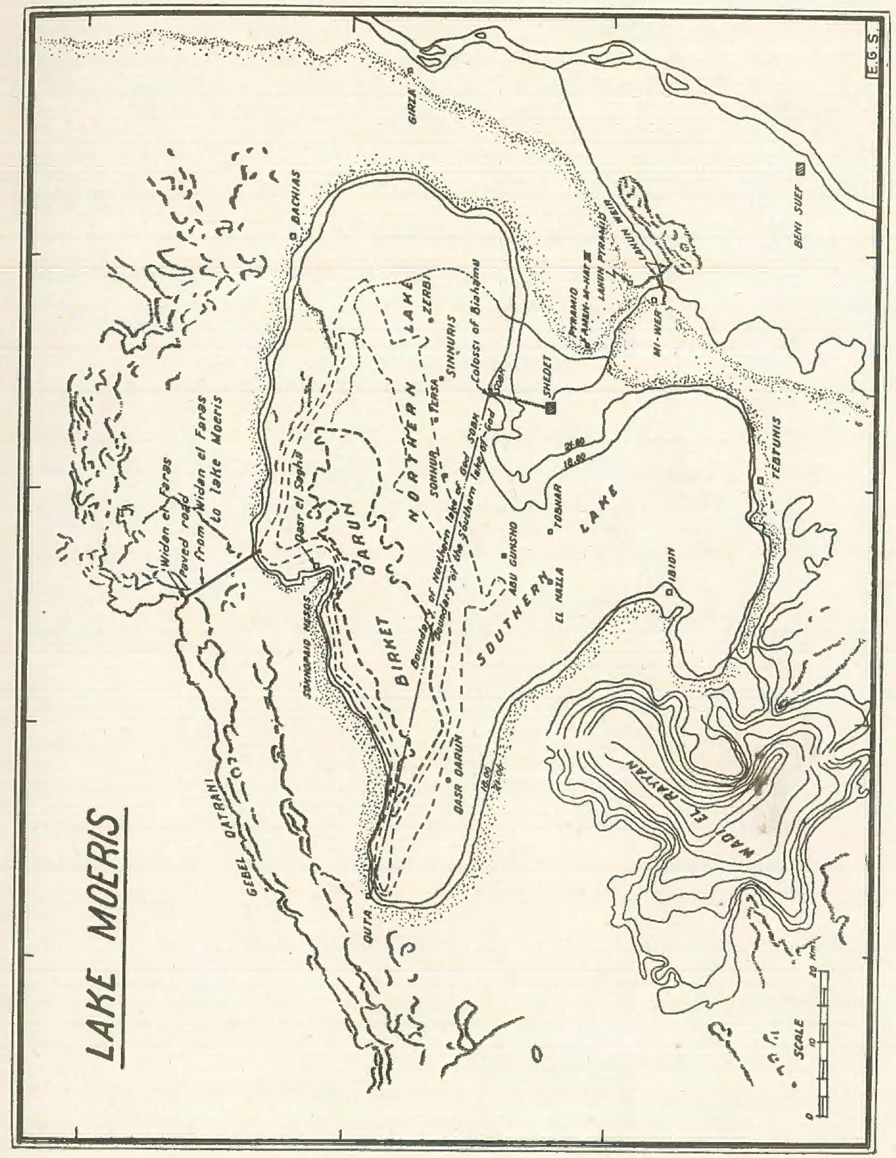


Fig. 1. Map of Lake Moeris.

The following study comprises a description of the Lahûn weir and Lake Moeris and summary of studies which could be found in the English and French books listed in the Bibliography.

2. *Summary of Hydrological Geological and Topographical studies :*

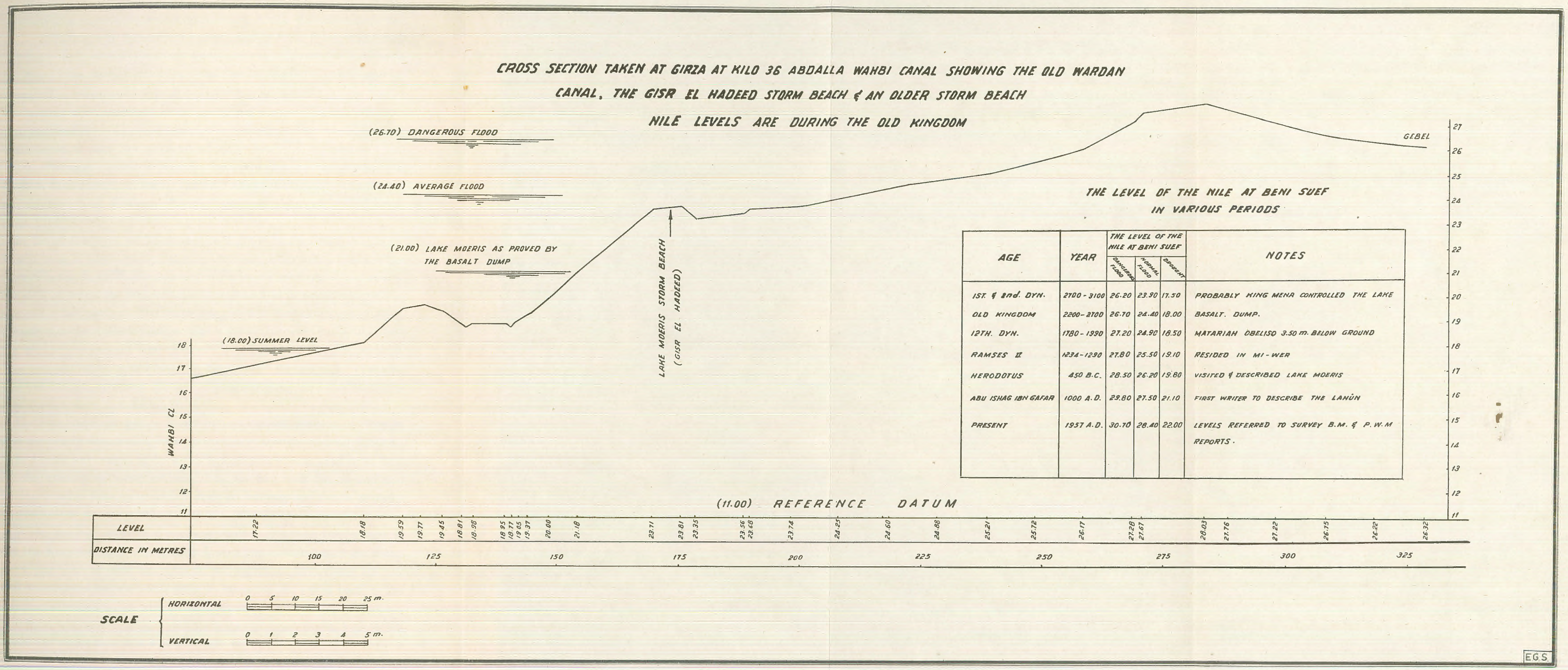
The accepted cause of the formation of the Fayoum, Qattara, Wady el Rayyan and other depressions of the Libyan desert is wind action. (Photo 1) which was taken in the Wadi el Rayyan depression and shows the horizontal strata in the remaining rock after the wind laden with sand has gnawed away the soft rock around it, is a vivid proof of the potency of wind action.

After the beds of marls and soft rock in the Fayoum have been scoured in the manner described above, the waters of an extraordinary high flood topped the Lahûn gap in the Palaeolithic period (about 10000 years ago), filled the Fayoum and deposited Nile silt (4-225). The gap began to silt up and the depression was covered to a depth of more than 10 m with Nile silt. Silt deposits could be seen in the Wadi and Batts Tamia Ravines which have cut their courses in many places to bed rock.

When the Nile valley was inhabited and the basin system of irrigation was developed by the Ancient Egyptians, the country was divided into two regions. Upper and Lower Egypt. The lake uncontrolled could have diverted 250 million cubic metres daily form the flood and in low floods this could retard the filling of the basins of Lower Egypt.

This is how the Pharaonic Kings of Egypt came in and built the Lahûn weir at a level and width so calculated as to pass ordinary floods to the basins of Lower Egypt, and also to divert the waters of high and dangerous floods to the Lake as shall be shown later.

The Fayoum lake has left its storm beaches at different stages of its existence. Geologists have studied the fauna of these beaches, the flint implements and pottery, which aided in fixing the dates and determining the quality of the lake waters. These beaches range from R. L. + 44 m to the present shore at R. L.-44 m.



THE LEVEL OF THE NILE AT BENI SUEF IN VARIOUS PERIODS

AGE	YEAR	THE LEVEL OF THE NILE AT BENI SUEF			NOTES
		DANGEROUS FLOOD	NORMAL FLOOD	DROUGHT	
1ST. & 2nd. DYN.	2700 - 3100	26.20	23.90	17.50	PROBABLY KING MENA CONTROLLED THE LAKE
OLD KINGDOM	2200 - 2700	26.70	24.40	18.00	BASALT. DUMP.
12TH. DYN.	1780 - 1990	27.20	24.90	18.50	MATARIAH OBELISQ 3.50 m. BELOW GROUND
RAMSES II	1234 - 1290	27.80	25.50	19.10	RESIDED IN MI - WER
HERODOTUS	450 B.C.	28.50	26.20	19.80	VISITED & DESCRIBED LAKE MOERIS
ABU ISHAG IBN GAFAR	1000 A.D.	29.80	27.50	21.10	FIRST WRITER TO DESCRIBE THE LAHÛN
PRESENT	1957 A.D.	30.70	28.40	22.00	LEVELS REFERRED TO SURVEY B.M. & P.W.M REPORTS.

Fig. 2. Cross Section of the storm beach of Lake Moeris and another older shore at Girza.

There is a continuous well marked beach which the inhabitants call « Gisr el Ḥadeed» or the railway embankment because it resembles such and lies at R. L.+25 to 22 m and has been found to consist of 5 different beaches by the late O. H. Little director of the Geological Survey of Egypt. The lowest yielded pottery with fresh-water shells attached to it. The pottery when examined by archaeologists was dated to periods later than the Neolithic. This lead Little to the conclusion that Gisr el Ḥadeed is the beach of Lake Moeris (4-210-32).

The Ptolomies started drying the lake and the land uncovered was given to Macedonian soldiers. The lake fell to R. L.-2 m (19-210-21) and the town Kom Washeem (Karanis) was near the shore and its Greek name gave the lake its present name-lake Qarûn.

In the middle ages, in Nabulsi's time (9) the lake fell to R. L.-30 m. Now it is at R. L.-45 m, but as new areas are put under cultivation in Quta, Gharaq, Kom Washeem, and new drains are constructed to improve the yield of crops, the lake will rise as estimated by the author in 1936, one and a half metres. The writer suggested at that time expropriating the cultivated land which was poor and cheap at that time, and prohibiting the sale of government land that will be affected by the rise in level. That proposal which would have cost the government only L.E. 150.000 was not heeded, and now the lake is steadily rising, and the cultivated land on the shore is suffering [1].

The lake does not get or loose any appreciable amount of seepage and the yearly evaporation from its surface is nowadays about 1.80 m. Lake Qarûn has ceased to be a riddle and now we can predict its level for the quantity of water entering it by the two main drains and also by the smaller ones, is recorded daily by reading the depth of water on the sills of weirs near their outfalls.

When the lake acted as a reservoir controlled by the Lahûn weir in the Old Kingdom its level was at R. L. + 21 m as sections on the dump show (fig. 3). At that time basalt was quarried from Gebel Qatrani and transported on sledges drawn by oxen on the paved road to the

[1] Those who want to obtain knowledge about the seepage into and out of lake Qarûn and evaporation from it, should refer to (8).

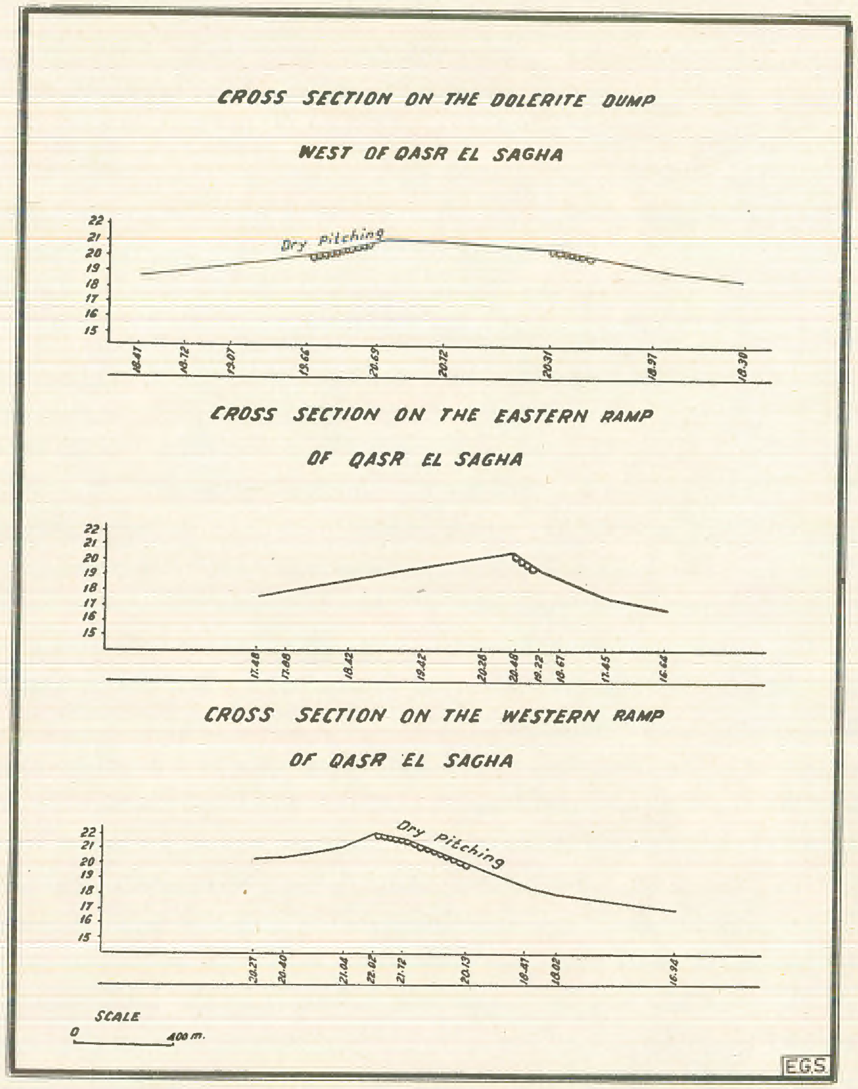


Fig. 3. Cross sections on 2 ramps opposite Qasr el Sagha temple and one on the dolerite dump.

dump at the shore of the lake, then carried in great sailing ships on the lake past the navigation opening in Lahûn, thence to the Nile to pave the mortuary temples of the pyramids.

The water of the lake was fresh for it discharged back to the Nile after the flood, and shells of its storm beach were fresh water shells.

In the days of Khûfû the Nile ordinary floods reached R. L. 24.20 m and in summer R. L.+17.80 m opposite Lahûn; and these levels could fill the lake to R. L.+21.00 and discharge it to a level of 18.00 m. The 3 metres depth of the lake contain about 6 milliards of cubic metres of water or more than the present Aswan Dam.

In the last days of Quta the village on the escarpment north of the lake, the level of the lake fell to R. L.-15 m, for a stone cause—way was found at that level. After that the people left the village as they left Dimé (Soknopaiou Nesos) in the middle of the 3rd century A. D. (17-21-2) for an obscure reason.

It was mentioned in the Arabic text that, this was due to the salinity of the lake rising above the limit of potability, but as will be seen later, that is not correct for the salinity could not have been more than 1.2 grams per litre.

When the lake fell to R. L.-30 m it reached the limit when its water could be used for irrigation, for «Nabulsi» says that before his time there were many sakias on the northern shore of the lake lifting water for irrigation, but only one sakia remained in his time.

Although the lake water had become too salty for cultivation yet it supported many varieties of Nile fish (29-15-12 to 16) in 1245 A. D. The labeo niloticus, tilapia, synodonton shal, and lates niloticus were the most abundant.

Now the lake is at its lowest (R. L.-45 m) and its salinity rose to 21.66 grams per litre in 1922. The fisheries suffered and the yield in fish from the lake fell from 4100 tons in 1920 to 483 tons in 1929. The fisheries department stepped in and introduced marine fish such as the mugil cephalis, and lately the sole and shrimp.

It is interesting to note that the quantity of salt in the water of the lake did not vary much since it was in connection with the Nile as the following table shows.

Quantity of salt in the Lake.

Period	Level R.L.M.	Area mill. m²	Capacity milliard m³	Salin kg./m³	Salt milliard kg.
Old Kingdom	+20.00	2100	52.9	0.325	17.12 (1)
1245	—30.00	450	5.9	3.00	17.70 (2)
1922	—45.00	214	0.8	21.50	17.20 (3)

Analysis of samples of the water of lake Qarûn after 1922 could not be obtained; but it is known that the salinity has risen quickly.

The quantity of salt in the lake has stood at 17 milliard (1000, million) kgs since it had direct access to the Nile from Pharaonic times up to 1922 A.D. Where then has gone the salts carried by the water entering the lake from the Nile and the drains? The only explanation is that the lake loses water by seepage.

The annual quantity of water carried by the drains into the lake is about 350 million m³ and contains 0.500 grams of dissoled salts per litre. The lake with a surface area of 214 million m² has only to lose at present 0.037 m (or nearly four centimetres) by seepage which is an insignificant figure compared with the amount lost by evaporation in one year (1.80 m). It seems that the lake is not now losing even this four centimetres for the salinity is rising and the lates and tilapia (bolti) sultani have disappeared.

The rise and fall of the Nile has been recorded in cubits (about 0.54 m) (39-10-2) on the Nilometre of Memphis in Ancient Egyptian times until the Arab occupation in 622 A.D. The Arabs transferred the Nile gauge opposite their capital Fustat (Old Cairo) where it stands to this day having been repaired by the Public Works Ministry in 1938. In the

(1) Nile water contains in floods at Cairo 0.130 gms. per litre dissolved salts (24-41) and assuming the quantity of flood water entering the lake 2 ½ times the water discharged to the Nile, the salinity of the lake will be 130 × 2.5 = 325 p.p. million (19-205).

(2) Siwa Oasis water contains about 3 gms of salt per litre.

(3) According to the average dissolved salts in 30 samples taken in 6 points in the lake in the period from 1/1/1922 to 1/1/1923-21.66 p.p. million taken 21.50 (8.19.8).

years 860, 1520, 1737 and 1886 A.D. changes were made in the value of the cubits for various reasons especially collecting taxes in low floods (1). The subject has been studied by Sayyid K. O. Ghaleb in book (21) and pl. XXXIX gives the value of the water level above mean sea level at the Nilometre (Mekias) of Roda at dates since 622 A.D. till now.

To compare ancient records with present ones; we have also to take into account the rise of cultivated land and consequently the rise of the bed and the flood of the Nile. This was proved at the latitude of Cairo to be 3.35 m in 4000 years, for the obelisq at Heliopolis erected by Senusert gives that figure (2).

This is equivalent to 8.8 cms per century and was taken at 9 cms by Dr. John Ball (19-174-16).

To check the accuracy of the foregoing figures let us take the statement of Nabulsi in 1245 A.D. that the Nile has never exceeded 20 cubits in flood. 20 cubits in 1245 A.D. on the Nilometre of Roda give us a level of R.L. 18.800 m. Assuming the records he was referring to were since the Arab invasion and of which he must have been well informed being in the service of the Ayyubite sultan Salih Ayyub, the level equals 19.80 m. The dangerous flood of 1874 A.D. reached on 5-6 September R.L. 21.40 or 1.60 m higher than the flood mentioned by Nabulsi. I have no records of the floods before Nabulsi to check his statement (3), but nevertheless, I have shown this flood on the drawing of Lahûn for lack of more precise information.

Herodotus mentioned (13-167) that in the days of Pheron son of Sesostris, «The river had swollen to the unusual height of 18 cubits and, had overflowed all the fields». Now this Pheron can be nobody

(1) I suspect other changes not recorded took place. Nabulsi states that the Nile has not risen above 20 cubits, but applying the diagram (pl. 39-21) the dangerous flood of 1874 would have been in Nabulsi's time about 23 cubits.

(2) The obelisq has been raised lately and in my opinion it should have been left at its original foundation.

(3) Herodotus mentions that the Nile rarely rose to 18 cubits. Applying the corrections for the rise of the bed of the Nile and of the Roda gauge in 860 A.D. that would be nearly the 20 cubits of Nabulsi. This proves that both historians gave correct statements and that the Ancient Egyptians made no changes in the Nile gauge.

else but Menephtah son of Ramses II sometimes referred to as Sesostris by the Greeks. He reigned 1250 B. C. and is considered by many Egyptologists as the Pharaoh of the Exodus. Assuming the old Nilometre at Memphis was not tampered with as seems probable that would mean a flood of 20 cubits in the days of the Ptolomies [1].

On the foregoing facts, I have prepared the following table showing the level of water above M. S. L. at the entrance to Fayoum in high floods, average floods and summer low levels.

Period	High flood	Aver. flood	Low water	Remarks
3100-2700 B. C.	26.20	23.90	17.50	1st and 2nd Dynasties.
2700-2200 B. C.	....	....	....	Old Kingdom.
2600 B. C.	26.50	24.20	17.80	4th Dyn.-Khûfû.
1990-1780 B. C.	27.20	24.90	18.50	12th Dyn.-Amenemhat III.
1300-1200 B. C.	....	....	....	19th Dynasty.
1290-1234 B. C.	27.70	25.40	19.00	Ramses II.
450 E. C.	28.40	26.10	19.70	Herodotus.
1000 A. D.	29.70	27.40	21.00	Abu Isḥaq.
1960 A. D.	30.70	28.40	22.00	Now.

3. *Lake Moeris as described by Herodotus.*

The first writer who gave us a description of Lake Moeris after actually visiting it was the Greek historian Herodotus known as the father of history. He visited Egypt during the Persian occupation about 450 B. C. The following is what he said about it copied from the translation of Rawlinson (13-191- Vol. I) Chapter 149, Book II :

« Wonderful as is the Labyrinth, the work called the Lake of Moeris which is close by the Labyrinth, is yet more astonishing. The measure of its circumference is sixty schoenes or 3600 furlongs, which is equal to the entire length of Egypt along the sea-coast. The lake stretches in

[1] If we consider the 18 cubit dangerous flood to be the highest recorded in the time of Herodotus as seems more correct it is equal to a 20 cubit flood in the time of Nabulsi.

its longest direction from north to south, and in its deepest parts is of the depth of fifty fathoms. It is manifestly an artificial excavation, for nearly in the centre there stand two pyramids, rising to the height of fifty fathoms above the surface of the water, and extending as far beneath, crowned each of them with a colossal statue sitting upon a throne. Thus these pyramids are one hundred fathoms high, which is exactly a furlong (stadium) of 600 feet; the fathom being six, and a foot four palms. The water of the lake does not come out of the ground, which is here excessively dry, but is introduced by a canal from the Nile. The current sets for six months, into the lake from the river, and for the next six months from the lake into the river. While it runs outward it returns a talent of silver daily to the royal treasury from the fish that are taken, but when the current is the other way the return sinks to one third of that sum».

Herodotus mentioned when describing the Labyrinth that his description is from actual observation, and as the Labyrinth which by the way was the funerary temple of the Pyramid of Amen-m-hat at Hawara, was on the shore of Lake Moeris, he must have obtained his information about lake Moeris from responsible people on the spot, and any divergence from what I have arrived at and shown on the map of lake Moeris (Fig. 1) can be explained.

Take for instance when he says that the lake stretches in its longest direction from north to south. That is not actually correct, for from Quta to Girza is 90 kilometres, and from the dolerite dump to the south shore is 60 kilometres. The mistake was due to the fact that the lake was divided for the purpose of collecting taxes on fisheries into two divisions, the Northern Lake and the Southern Lake; as recorded on monuments and papyri which will be discussed later.

The boundary on the west was fixed by the stela at Quta, found and described by Daressy and its eastern boundary was the colossi of Biahmu. His description of the colossi of Biahmu is exaggerated and he did not visit them, but when his informant told him they were in the middle of the lake meaning the boundary between the two halves, he concluded they were in the centre of the lake and as he said the lake was fifty fathoms (90 m) deep, he concluded that the pedestals on which the statues were seated (exagerated by him as pyramids) are 50 fathoms deep. Actually the land at Biahmu is at R.L.+18.00 m and as the lake in flood was at

R.L.+21.00 m the colossi were only in 3 m depth of water. His statement about the depth of the lake as 50 fathoms was correct, for lake Qarûn is now at R. L.—45.00 m and 12 m in the deepest part, and as lake Moeris was at R. L.+21.00 m in flood the total depth would have been 78 m and as the drains carried an enormous amount of silt in scouring their ravin esespecially the Wadi and Batts drains, and deposited it in the lake, the 12 metres difference are due to this silt.

Herodotus says that taxes collected on fisheries when the water was entering the lake i. e. in flood were one third that when the water flowed from the lake to the Nile i. e. in summer. Nabulsi says also (29-152-5) that the lake contains innumerable species of fish which were caught in large quantities when the Nile was low, but in less amount when the lake was being filled in flood. The lake in Nabulsi's time (1245 A. D.) had dwindled to a mere shadow of what it was, and no wonder the taxes on fisheries from lake Moeries were enormous and reached a talent of silver daily.

4. *Lake Moeris existed during the Old Kingdom and continued to early Ptolemaic times :*

No lake at a level below the Nile summer lever at Lahûn could have fed the Nile with water stored during flood, and act as a reservoir, and for this reason no ruins or towns before Ptolemy II have been found till now below R. L.+18.00 m.

Mention of great reclamation works from Lake Moeris in the reign of Ptolemy II (285-247 B. C.) is recorded in «The Flinders Petrie Papyri» (19-183-8).

After the Nile in an exceptionally high flood broke into the Fayoum and scoured the gorge connecting its valley with the depression to R. L.—17 m as shown by the borings carried out by the Fayyoum Irrigation Circle in 1933, Nile silt covered the bed of the depression to the thickness one finds in the Wadi and Batts Tamia ravines.

The capacity of the Fayoum lake between R. L. 22 and 17 m is about 10 milliard m^3 and in an ordinary flood of 600 million m^3 per day, the lake if uncontrolled could subtract a daily discharge of 250 million m^3 or about 40 % of the discharge to fill the lake in 40 days which is the

period of high level in ordinary floods. This would have a very bad effect on the irrigation of Lower Egypt and deprive its basins from the beneficial effects of the Nile silt. From this it is apparent that the lake must have played an important role in uniting Upper and Lower Egypt.

Herodotus says (21-161) that before King Mena, the first King who united Upper and Lower Egypt, the Nile used to run near the Libyan desert, and that he closed this channel at a distance of 100 stades, (20 km) above (upstream) Memphis and made the river run between the two deserts.

This shows that the main channel of the river ran in the present Bahr Youssef and its extension the Lebeini, because the uncontrolled Fayoum lake diverted a big part of the flood.

In the time of Mena the Egyptians built only with mud bricks and it is not probable that he made a masonry dam. He could have built an earth bank at Hawara and made a spill way to the lake of rubble stone on the site of the present regulator where the bed is rocky and at R. L. 19.50 m, and as it required a lot of maintenance after every flood, it would have been replaced by a proper masonry weir in the 3rd or 4th dynasties who built the pyramids and knew the hydraulic mortar of lime and burnt brick powder (homra).

To obtain proper control of the flood waters the masonry works in the form of weirs would have to be built at the bifurcation at Lahûn. When the Ptolomeys began drying the lake, the discharge of Bahr Youssef fell and the channel began to silt to such an extent that the problem became how to obtain more water for the Fayoum and Nabulsi recounts three unsuccessful attempts by the Lahûn engineers who were in charge of the work at his time to increase the summer supply of Bahr Youssef without success, in fact Nabulsi says matters became worse. For this reason we do not find the weir closing the Fayoum branch and it must have been removed before his time.

I am inclined to believe that the Lahûn weir described by the Arab writers could not have been the Ancient Egyptian weir, but built on its lines. Irrigation works require continuous repairs and in unsettled periods are short lived. As to the persistence of types through centuries I put before the reader the width of the navigation channel in the weir.

It was 20 cubits [1] ذراع العمل i. e. 15 m. Happening to visit the famous boat of the sun lately discovered at the big pyramid of Khûfû, I interested myself by measuring its dimensions and its oars, for to pass the Lahûn weir in a pleasure trip after the flood in winter, it had to use the oars against the current, and I found that it needed 13 metres or barely one metre clearance on each side. This pleasure boat which in fact was much like our present day «Dahabiah» must have been of the maximum size afloat on the Nile. When the Delta Barrage was built, the width of the Rosetta branch lock was also 15 metres to pass the biggest boats (alfiyya). So from Khûfû till this day the size of the biggest sailing boat has not changed.

For discharging the lake back to the Nile after the flood as described by Herodotus I think the site occupied now by the old disused regulator on the right bank of Bahr Youssef, where the rock sill does not exist, must have been used for discharging the low stage of the lake to R. L.+17.50 and allow ships to pass to and fro.

This old regulator has 8 openings each 2.4 m wide and in its middle is an opening 5.8 m wide which could pass fishing boats and medium sized cargo boats with movable masts (38-pl. 2). I do not think this regulator existed in Pre-Arab days but it is on the site of one described by Diodorus Sicèlus (11-44-16), for he said that there was a big canal between the Nile and Lake Moeris. Its width was 3 plethra and its length 80 stades, and the Labyrinth was 30-40 stades far from the inlet of the canal into the lake.

The bahr Youssuf was a great natural branch of the Nile and the canal would have been fed from it at Lahûn and ran 11.4 kms to this regulator which is nearly 80 stades; for the stade of Herodotus has been checked by measuring several lengths mentioned by him and found equal to 130 m (32-253-19).

This regulator is 30 stades from the Labyrinth, which as previously mentioned, was the funeral temple of the pyramid of Amen-m-Hat III

[1] ذراع العمل or cubit of work equals 0.768 m (39-12-6) and taken by Mahmud Pacha el Falaki as 0.750 m.

at Hawara and his colossi were seated on pedestals at the low water shore of Lake Moeris; for this was proved by parts and inscriptions of the statues found by the late Sir Flinders Petrie.

The mortuary temples of the pyramids of Giza and Abu Sir are paved with basalt blocks which came from gebel Qatrani north of Fayoum and not from Abu Zaʿbal which was not quarried by the Ancient Egyptians as proved by the late Dr. Lucas who made chemical analysis of these stones (23).

Beadnell (15, pl. 18) showed a paved road north of lake Qarûn leading to Widan el Faras, two black hillocks in gebel Qatrani that from a distance look like the ears of a horse. I have visited this road and found it 2-2.5 m wide. I followed the road for about 7 kilometres on the plateau north of the escarpment and Miss Caton Thompson found a tank at the edge of the escarpment with the horn of an ox (Ancient Egyptian type) in it. This tank was filled with water for man and beast to quench their thirst after climbing 140 m from the lake to the plateau.

The Qatrani hills have a strata of basalt 20 m thick and with blocks strewn on its face due to denudation of the underlying stratas [1]. The ancients picked suitable blocks and loaded them on sledges drawn by oxen on this road to the dump on the shore of Lake Moeris (Fig. 4) where blocks still waiting for shipment can be seen today.

I delegated an engineer to make cross sections on this cause-way and also on two ramps with dry stone pitching on the lake side still in place (the oldest dry stone petching known in the world). These stone pitchings have protected the banks from wind erosion.

Remains of older dumps and ramps can be seen in the vicinity where basalt and sandstone blocks are scattered here and there on the lake deposit proving that due to some high flood, the control works at the mouth of the lake have failed and the flood waters rushed into the lake and raised its level and the winter gales destroyed the pichting.

This basalt is hard and has been used as hammers for shaping the enormous piles of stones in the pyramids and temples and statues and

[1] They look as black as tar قطران .

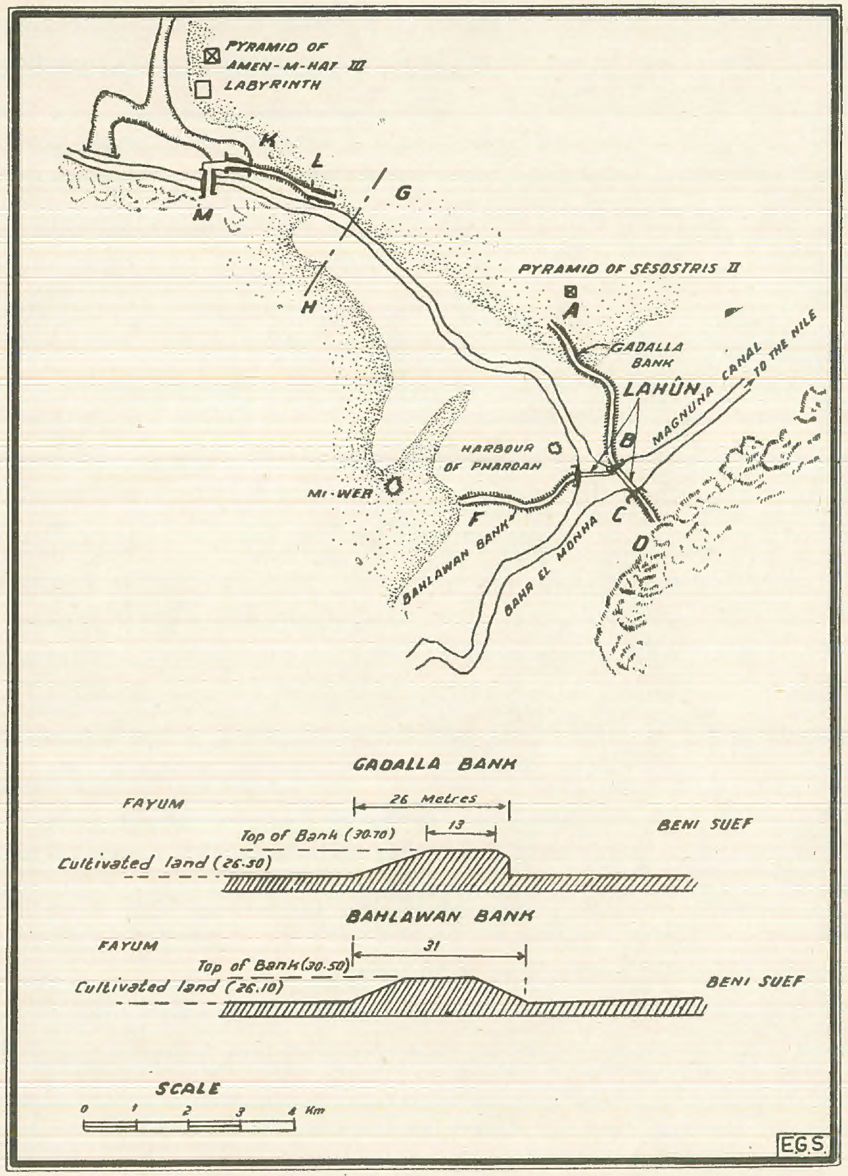


Fig. 4. Site plan, showing the Lahûn, the Hawara rock barrier, the inlet of lake Moeris, and ancient monuments and banks.

sarcophagi and one may imagine the brisk traffic in it and its transport across the lake past the lock in Lahûn weir which will be described later with its navigation passage 15 m wide.

In the days of Khûfû who paved the funerary temple of his pyramid at Giza about 2600 B. C. with basalt blocks, the average flood level at Lahûn was R. L. 24.20 m and the summer level was at R. L. 17.80 m and this could permit the lake to rise to R. L. 21.00 m and this would leave all the Ancient Egyptian monuments, temples, causeways and ramps above the lake. The Qasr el Sagha temple is the funerary temple of the tomb of some important person not yet discovered among the tombs in the cliff north of the lake. I recommend the Antiquities Department to encourage some society to carry excavations in this zone before it is too late, for tomb thieves are carrying an active business since 1935 when I was inspector of irrigation in Fayoum.

Archaeologists have searched in vain to find Ancient Egyptian monuments below the level that would allow the lake to discharge its stored water back to the river and as this is one of the most important proofs of the existence of this reservoir, I have checked the levels of the following monuments by engineers of the Fayoum Circle of Irrigation :

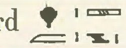
SITE	R.L. above M. S.
Paved floor of Qasr el Sagha temple	+35.00
Top of eastern Qasr el Sagha ramp	+20.48
Top of western Qasr el Sagha ramp	+22.04
Top of dolerite dump	+20.72
Pavement of Madinet Madi temple	+25.94
Pavement of Tebtunis temple	+25.40
Ground on which rest the pillars of the temple of Amen-m-Hat in Kom Fares	+24.00

As shown above none of them is below the flood level of Moeris except the dolerite dump, but it was eroded at least 1.5 m by wind action. Dimé ruin to the north of lake Qarûn was called in Ptolemaic times Soknopaio Nesos or the island of the crocodile and in fact it is on a hill rising to R. L.+25 and with the lake at R. L.+21.00 would have been an island with crocodiles from lake Moeris basking in the sun on it.

The stela of Quta is a very important evidence of lake Moeris. It was made of a basalt block 2.10 m×0.88 m and its thickness varied from 0.40-0.48 m and the following 3 lines of inscription were copied by M. Daressy in the Annales of the Antiquities Dept. of 1899. I give a copy of it and its translation by Dr. Ahmed Fakhry (36-900) which appeared in the Annales of the Antiquities Dept. 1942.

Line (1) boundry of the southern lake of the god Sobk.

Line (2) boundry of the northern lake of the god Sobk.

Line (3) was not so easy to translate owing to a mistake in copying by M. Daressy or in the original and should be replaced by and the word  would mean on the shore of the lake and the full text « This stela has been (erected) on the shore of the lake by the head of the village of Nekht».

That the lake was divided into two divisions north and south is corroborated by its description by Herodotus that the lake stretches in its longest direction from north to south. Although that was not correct yet that is what he concluded when they told him it was divided into two sections north and south and he may be pardoned this mistake for he had no map before him. He made another mistake when they told him that the colossi of Biahmu were on the boundry between the two divisions and concluded that they were built in the centre and deepest part of the lake, and as the foundation of the pedestals was at the low water level, they in flood would have been in the water of the lake.

In 1937 Dr. Ahmed Fakhry bought a statue from an antiquities merchant (Agaibi) in Fayoum for the Cairo Museum, and it turned out to be that of an overseer of both the Northern and Southern lakes, as written on its back and translated by Sir Alan Gardiner. This statue was said to have come from Kom Madinet Madi [1]. This is reasonable for

[1] Ibion in Ptolemaic times.

the fisheries from the Gharaq shelf would have been important and this overseer would have to reside close to prevent poaching. Another statue of an overseer of the lake was found in the temple of Dimé. His name was Sobek Hotep and was buried in Thebes. His title as translated by Sir Alan Gardiner was « Mayor of the Southern Lake and the Lake of Sobk. Ramses II kept his favourite wife Ma-Nefru-Hara in Mi-Wer-Madinet Ghurab which was near the outlet of the Lake. One can picture how this king came in his pleasure boat from his summer capital Pi-Ramses on the Pelusiac branch north of Faqus to spend some time in winter at Mi-Wer. His boat would anchor at Lahûn weir and he would reach his palace by way of the Pharaonic bank known as Bahlawan bank. Mi-Wer had a harbour named in the Wilbur papyrus « The landing place of Pharoah in Mi-Wer».

5. *Lahûn or Ro-Hûn* [1] :

The Nile flood in the days of Mena, the first king who united Upper and Lower Egypt under his rule, reached the following levels : R. L. + 26.20 m in high floods, and 23.90 m in moderate floods and the water in summer fell to 17.50 m opposite Lahûn the entrance to Fayoum. The king of Upper Egypt in whose land lies the Fayoum, at its northern limit would have been in a position to control any work that may have existed to ensure the filling of basins in Lower Egypt. Hence the Fayoum lake was one of the reasons that prompted the unity of the two lands, and Mena who was a king of Upper Egypt must have used this lake to this end.

Herodotus (21-161 vol. I) mentions that the Nile used to flow near the Libyan desert and Mena closed it south of Memphis and diverted its course to the middle of the valley. Some irrigation engineers said that this refers to the construction of the west bank of the Nile, but I think it refers to the construction of some work in earth and rubble stone to regulate the flood waters entering the Fayoum lake for in the First dynasty they built in mud bricks and only a few cases of burial chambers built of small stones imitating brick-work bonding are known.

[1] The name was mentioned by Sir Alan Gardiner in (2) under the number (392A) and was not followed by the determinative as noted by him. Now we know it is not the name of the village of Lahûn; it was the name of the big weir.

The importance of such a spillway on the rock sill at Hawara was apparent to me after studying Wadi Gizan project in Saudi Arabia. For in dangerous floods the inhabitants fare worse than in dry years. The Wadi often breaches the earth dams (ogom) before the land is flooded and changes its cource, ruining the village and the seeds needed for cultivation. I imagined how Lower Egypt benefited from this magnificent control work. This rubble stone weir would have given a lot of trouble and needed much maintenance and in the time of Snefro the father of Khûfû masonry in stone and hydraulic mortar of lime and burnt brick powder (homra) was known and a masonry weir would have been built to feed the lake with surplus water in high floods and discharge back the stored water to the Nile through openings incorporated in the building (see fig. 5) to serve two ends, for it helped navigation in low summer levels and expedited the transport of the beautiful white limestone of Tura to the temples of Lower Egypt. This is also needed to empty the reservoir and make it capable of taking an appreciable part of the next flood should it happen to be a dangerous one.

The site of this weir could not be at the present regulator of Hawara on the stone sill whose level is R. L.+19.50 m (38-26-13) would have prevented the emptying of the lake in summer to the Nile to a level of R. L. 17.50 m. Most probably its site is the one now occupied by the old regulator on the right bank of bahr Youssuf upstream Hawara and described in the previous chapter.

This weir which would have to be a big masonry structure with provision for passing the biggest ships plying up and down the Nile could not have been the Ro-Hûn mentioned in Ancient Egyptian papyri (2-A 392) for it was not the mouth of the canal but the tail, and would have another name. The control of the flood waters would demand the building of some regulating work at Lahûn and most probably it was in the form of two weirs one on the feeder canal of the lake and the other on the main channel that flowed to the Nile. The latter weir was the one that was in the site of the Lahûn described by the Arab writers and similar to it, for regulating works on rivers suffer much from scour and require great care.

Nabulsi described this weir which was last seen in his days (1245 A. D.) and said it was the work of the Ancient Egyptians and was of the same

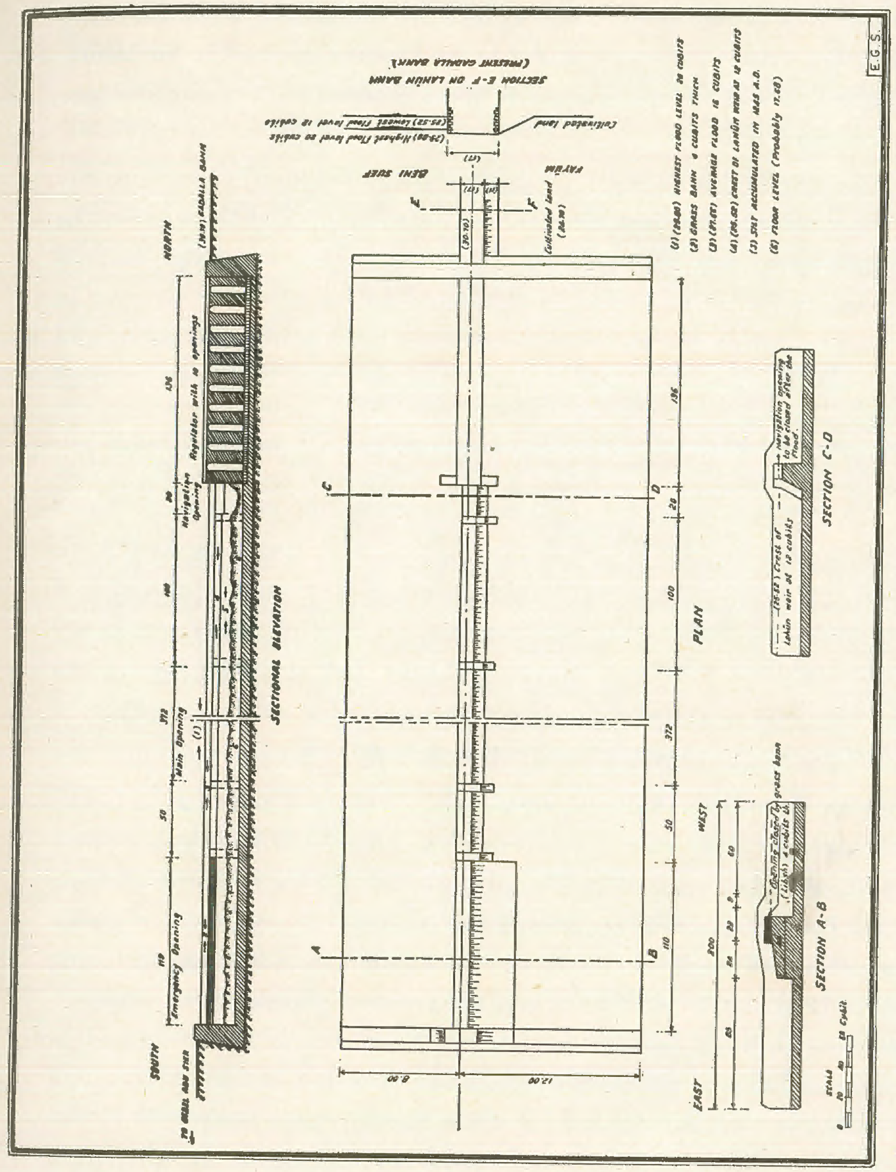


Fig. 5. The Lahûn, as described by Abu Isḥaq Ibn Ga'far in 422 A. H. and Nabulsi in 642 A. H. — 1245 A. D. Dimensions in 'Amal cubit = 0.768 m. Levels in metres above mean S. L. (Shown in Brackets).

category as the pyramids of Giza and the Pharos of Alexandria and known as Lahûn.

This weir was not built on the canal entering Fayoum, but was built on the extension of Bahr Youssuf called by Nabulsi Al Monha that joined the Nile some distance downstream. This weir was joined by another

similar work on the feeder canal of lake Moeris forming a colossal automatic distribution structure similar to the Fayoum «nasba» at the bifurcation and was at the eastern end of the Pharaonic bank now called gisr el Bahlawan.

When the Ptolemies began drying the lake and diminished the quantity of water entering Fayoum, the channel began to silt and the weir on the Fayoum canal was removed, for Nabulsi says that the water entered Fayoum by an open channel, and the old Lahûn regulator was not in existence. In fact the Fayoum suffered from insufficient water and especially the summer supply which goes to prove that bahr Youssuf dwindled in size.

The other source describing al Lahûn is the part copied in Maqrizi from a now lost book المنهاج في علم الخراج whose author in his turn quoted from another lost book دستور أبي اسحاق بن جعفر compiled in 422 A. H. These lost books were government registers of taxes on agricultural land and contained regulations concerning the working of public canals and banks and their maintenance. Judging from these that have come down to us as قوانين الدواوين لابن مماتي they were compiled by officials in charge of collecting taxes and contained reliable information.

As for Nabulsi, he was an exceptionally gifted man, and of an integrity not shared by many writers of the middle ages who relied much on hearsay and their books contained much nonesence. To give the reader an example of his honesty in recording facts, I quote the following translation from the preface of his book (29-3-17) : «I have refrained from including in this book the lies of folklore and the incorrect statements of historians who described old nations and only included statements that stand to reason and can be accepted by qualified persons; for many stated in their books that the Pharaoh in whose ministry was Joseph, when the latter grew old the courtiers who envied his post said to his king, your minister is now old and does not earn his salary by profitable work to the country, and we recommend you to decrease his pay. Pharaoh promptly told Joseph of this and asked him to go to the Fayoum lake and drain its water and reclaim it for cultivation. Joseph went there and asked God the Almighty to help him drain the lake and reclaim it,

and God helped him with angels and the canals ran with water and the land flourished.

«Now the time that passed since Joseph is long and conditions required for correct statement by reliable recounters are lacking, and I think if such things actually happened, these would have been mentioned in the Koran, for God the Almighty has recounted in his Koran many of his accounts and called them the best accounts. Nevertheless believing in lies and discrediting facts are both mistakes and God alone knows what took place».

I have translated the foregoing to give an example of his honesty and unbiassed attitude in recording statements and observations in a book he wrote by order of his king Salih Ayyoub for the royal library. As to his intelligence and correct selection of sources and persons who supplied him with technical information, and at their head, I put the canal overseer خولي البحر who was the equivalent of the present day inspector of irrigation, he was beyond criticism, and the reader may obtain valuable information of the Fayoum irrigation as described by Nabulsi in 1245 A. D. published by the Royal Geographical Society of Egypt, 1940.

Nabulsi seems to have read the book of Herodotus or at least those who supplied him with information did as concluded by the late Dr. John Ball in his book (19-22-26). Nabulsi said (9-14-16) that the learned men of Egypt were able to irrigate the land even when the Nile flood was as low as 12 cubits, and protected the country even when the Nile rose to 20 cubits in flood, but alas! this knowledge and these works have disappeared from Egypt since 2600 years, and nothing remained of these works and knowledge except the Fayoum. Now Nabulsi wrote his book in 1245 A. D. and Herodotus lived in 450 B. C. and said that King Moeris lived 900 years before him. Adding these years we can say that king Moeris who is supposed to have made this magnificient work lived 2595 years before Nabulsi which is only 5 years short of what Nabulsi said.

Thus I was satisfied that the sources from which I have prepared the plan and elevation of the great weir called by the Arab writers Al Gidar al Youssufy known as Al Lahûn are reliable and worth publishing.

I have tried in vain to obtain a description of Lahûn from other ancient

writers but only found the name mentioned in Quatremere, *Mémoires Géographique et Historique sur l'Égypte*. In page 413 mention is made of Lahûn Stone as near the convent of Isḥaq. In the book of Amélineau, *La Géographie de l'Égypte à l'Époque copte* in page 182 is said that the Romans put a garrison at Lahûn stone to defend Fayoum and spy on the Arab invaders.

I will give the text describing the weir by the two Arab writers to enable the reader to follow it on the drawing (fig. 5) and see that it conforms with the description.

This is what Abu Isḥaq Ibn Gaʿfar said in 422 A. H., 1031 A. D. «Al Hagar al Youssufy is a wall built in bricks and lime mortar known as —sarûg —or lime and oil. The structure extends from north to south. At its southern end, it is joined by a wall going from west to east and bounded at its ends by two slopes. Its length is 200 cubits (ʿAmal) : At 80 cubits from the western end of this wall, it is joined by the southern end of the great wall. The use of this great wall is to divert the water when it reaches 12 cubits to Medinet al Fayoum. The length of what joins the east-west wall then joins the slope then runs lower from the end of the slope to a similar slope on the other side on the north is 50 cubits. The distance between the two slopes which is the low part is 110 cubits and 4 cubits deep. This low part is closed by a bank of grass called — libsh لبش. — The width of the (weir) on which the water runs on the libsh to the east is 40 cubits and holds the second libsh. To this slope on the north is a wall 372 cubits. The wall then falls at the end of this length for a distance of 100 cubits on its extension going east [1]. It then falls lower for it is joined by a length of 20 cubits. The amount of depression is 2 cubits and is closed by a bank of grass called libsh. The length of the remainder of the wall to the north is 137 cubits and is paved in ashlar and contains a regulator built in stone and in olden days was used to divert the water to Fayoum by way of the old canal which is closed by sadds [2] nowadays and it had gates on 10 old

[1] East should be corrected to north to be on the extension of the weir. It is a mistake by the copyist.

[2] Earth banks to close a channel.

openings. The total length of the great wall is therefore from its end 772 amal cubits not counting the wall going from east to west».

The foregoing is what Abou Ishaq said in describing the weir. He said the weir extended from north to south and that would make it a continuation of Gisr Gadalla which must have been a very old bank as it starts at the foot of the Lahûn pyramid. He fixed the level of the crest of the weir at a height when the Nile reaches 12 cubits and this is the level also given by Nabulsi. On the southern extremity of the weir there was a wing wall 200 cubits of which 120 cubits were downstream and that would give ample protection against scour. The northern end of the weir must have had a wing wall for the regulator, but it must have been overlooked by Abu Isḥaq or else was demolished by the inhabitants for building. Starting from south to north we have an opening in the weir 110 cubits and lower by 4 cubits (3.00 m.) than the crest, its crest was 40 cubits long and that length was needed to fix a bank of dry grass (libsh) to close the opening to the level of the crest for the water to run over it, but in dangerous floods the grass could be removed and give the weir an extra waterway, and ease the pressure on the canal banks at Hawara el Maqta famous for its breaches. Then follows a wall above water level 50 cubits long. After that the main weir 372 cubits long follows. In alignment with the weir there follows a wall 100 cubits long and goes north not east as wrongly mentioned in the text and it would be like the 50 cubits wall south of the opening [1]. The navigation opening then followed and was 20 cubits wide to pass the biggest Nile boats as previously explained. Its crest was 2 cubits lower than the main weir, and as the draught of the heaviest boats when laden is about three cubits, it is suited to pass the boats in floods as low as 14 cubits (average floods were 16 cubits). In ancient Egyptian times the opening would have been as deep as the floor to pass ships in summer. This navigation opening was not left after the

[1] The extra length of this wall is to keep the boats away from the turbulance of the main channel. I consider that it had a wing wall «going east» at its northern end so that boats would not be drawn by back currents and this may account for the mistake in the description.

flood, for water was needed to mature the winter crops, and Nabulsi gave us an interesting account of how the Lahûn engineers closed this opening as you will see later. The navigation opening was followed by a big regulator with 10 openings provided with doors, which was not used at the time and after 200 years it disappeared altogether for Nabulsi mentions nothing about it. It was built in ashlar and its floor was paved in heavy stone, and as it was not used, for the discharge of bahr Youssuf dwindled as shown previously, the inhabitants of the newly founded village of Lahûn would use its stone for building and making lime. The reis of Lahûn regulator showed me a place in Lahûn village where we dug and found parts of a wall in ashlar which may be part of the old weir and I hope some day excavations be undertaken to give us some information about the site and floor level of this great weir.

This regulator with 10 openings was built with fine picked ashlar and had a floor also paved in ashlar and as shown on the drawing (fig. 5) its level was 15 cubits below the crest of the weir or R. L. (17-68) enabled the discharge of Lake Moeris at low Nile in summer R. L. 18.00 m.

Adding the lengths given by Abou Isḥaq they total 788 cubits which is nearly as the total he gives at the end of his description as 772 cubits.

The description of Nabulsi is not detailed as that of Ibn Gaʿfar, but contains valuable information about the height of the weir above the floor 15 cubits and the silt accumulated upstream and the navigation opening and how it was closed after the flood and why this closure was essential.

He said (29-6-9) that the bahr el Monha takes from the Nile just upstream Zawiet Surbâm (Deirût) and crosses the Ashmonein and Bahnasa nomes, passing Bahnasa town on its shore, it reaches the Lahûn covering a distance of 4 days on horseback. The Lahûn is an elaborate engineering work perfectly built in stone joined by lead plates and iron dowels and rises above the canal bed to a height of 15 cubits. This edifice diverts the water of this canal to the Fayoum for without it the water will go down-stream to the Nile.

When the flood waters subsided and the water entering the Fayoum was barely sufficient to meet the needs of irrigation, it was necessary to stop escaping water to the Nile by means of the 20 cubits opening

for navigation before mentioned. This was accomplished by obtaining a palm log and tying round it stalks and grass. Ropes were tied at each end and the contraption was floated upstream the opening guided by the ropes. The current took it to the opening where men carrying earth in baskets filled the opening and made it water tight and one could pass dry shod to the desert of Qai now called the desert of Abu Sir.

Bahr el Monha has dwindled in size like many other branches of the Nile some of them you could jump from bank to bank.

I have followed the discharge of bahr Youssuf and found a record taken by Linant de Bellefonds in the flood of 1853 A. D. which was a high one similar to that of 1938. The daily discharge of the Nile at gebel Silsila was 930 million m³. At that time the Bahr Youssuf was without a head regulator or regulators at Abeed, Saqûla and Mazûra and was exactly as in the days of Nabulsi. Linant measured its discharge at Bahnasa and Dishasha and found it 40 million m³.

I have calculated the discharge that could have passed the weir in a dangerous flood of 20 cubits and an average flood of 16 cubits and as the flood of 1853 was similar to the 1938 flood it was a mean between a dangerous (1874) and an average (1949) flood. I have assumed that the Fayoum in flood obtained a discharge of 20 million m³ for irrigation and the fisheries of the lake. The regulator was closed and not used as mentioned by Abu Isḥaq and the 110 cubit weir at the southern end of Lahûn was fully open in a dangerous flood with the grass bank removed. The result was that assuming an average velocity over the weir of one metre per second, a discharge of 190 million m³ passed daily in a high flood upstream Lahûn weir and 80 million m³ in an average year. In a year like 1938 [1] which was as said before similar to the year 1853 a discharge of 130 million m³ passed Dishasha in the 10th Century A. D. compared with 40 million m³ as measured by M. Linant de Bellefonds in the high flood of 1853.

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[1] The following are the maximum levels recorded at Roda :

1874 a dangerons flood, R. L. 21.40 m.
1938 a high flood, R. L. 20.29 m.
1946 an average flood, R. L. 19.28 m.

In the 13th century the discharge of bahr Youssuf fell also for no mention is made of the 110 cubit span of the weir which was closed by a bank of grass and the regulator was not described by Nabulsi who is a very keen observer and the weir was said to have been deep in silt upstream and no wonder the weir was removed altogether a few years after Nabulsi and earthern banks were the only means of regulating with ordinary regulators and the old Lahûn regulator wa built in Mamelûk days.

In the days of lake Moeris the lake would have taken at least 250 million m^3 in high floods to be of any use to the country as a flood escape basin, and the bahr Youssuf must have been a big branch of the Nile, bigger than the present Damietta branch, and when the Ptolemys began restricting the discharge entering the Fayoum, they must have revised the dimensions of the Fayoum weir and the Nile escape weir diminishing the first and enlarging the second. This is born by the fact that the regulator of 10 openings was built in ashlar with a floor also in ashlar and was built to discharge lake Moeris to the Nile when it fell to R. L. 18.00 m as previously mentioned, whereas the weir was in burnt bricks which was not used by the Ancient Egyptians as far as I know. This big section of the bahr Youssuf helped to maintain a high summer supply to the Fayoum from infiltration along its deep channel and even let in part of the summer supply of the Nile at its mouth at Deirut. Nabulsi was not wrong when he said (9-6-15) that bahr al Monha in olden days at its head ran with water 8 months and was dry only 4 months where—as in his days the reverse happened.

To fix the level of the crest of the weir which was at the level of a low flood of 12 cubits, I have used the level of the dangerous flood of 1874 which reached R. L. 21.40 m at Roda guage as equivalent to the 20 cubit flood mentioned by Nabulsi as the highest flood recorded and known to him. At Beni Suef opposite Lahûn the level would be R. L. 30-74 m. Taking into consideration the rate of rising of the floods as 9 cms per century this is equal to 29.84 at Lahûn 1000 years ago. Similarly the crest of the weir at 12 cubits was at R. L. 25.52 m and an average flood of 16 cubits R. L. 21.68 m.

The level of Gadalla bank now is R. L. 30.70 m and as it is a continuation of the Lahûn weir and has a masonry dwarf wall on its eastern

face to protect it [1], it would have stood one metre above a dangerous flood in the days of Abu Isḥaq.

Irrigation engineers have always wondered at the big size of Gadalla and Bahlawan banks, but now you understand that that was essential to protect the Fayoum in Dangerous floods.

Let us hope that engineers reading this note who may chance to see manuscripts describing old irrigation works or to visit ruins of weirs and dams or canals, would add to our stock of knowledge by bringing to light such information. In fact this is very probable, for I bought a manuscript written about 980 A. H. (about 400 years ago) during the Turkish rule describing and giving the length of public canals and banks in qassabas and shows how backward irrigation was in those days. It is only under powerful, independent and just rule that irrigation works blossom.

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[1] This wall was last repaired more than 100 years ago, and as the basins will be converted in the next five years to perennial irrigation, no more breaches of the Delgawi basin which cause high floods in bahr Youssef will occur and the two banks Bahlawan and Gadalla will pass to history.

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N. B. In the text reference is made to the above books by the number in the list, the page and the line, thus (29-24-14) means تاريخ الفيوم للنابلسى page 24 and line 14.

Photo 1. — Limestone tower left in Wadi el Rayyan after the surrounding softer stone was scoured by wind born sand.

Photo 2. — Water is distributed in the Fayyoum by weirs today and the practice was since ancient times.

PHOTO 3. — Qasr el Sagha is the mortuary temple of an unkown noble whose tomb has not yet been discovered and was on the shore of Lake Moeris.

PHOTO 4. — A ramp for boats crossing the lake with visitors for Qasr el Sagha.

PHOTO 5. — The paved road from gebel Qatrani to the dolerite dump on the shore of lake Moeris.

PHOTO 6. — The dolerite dump at the end of the paved road.

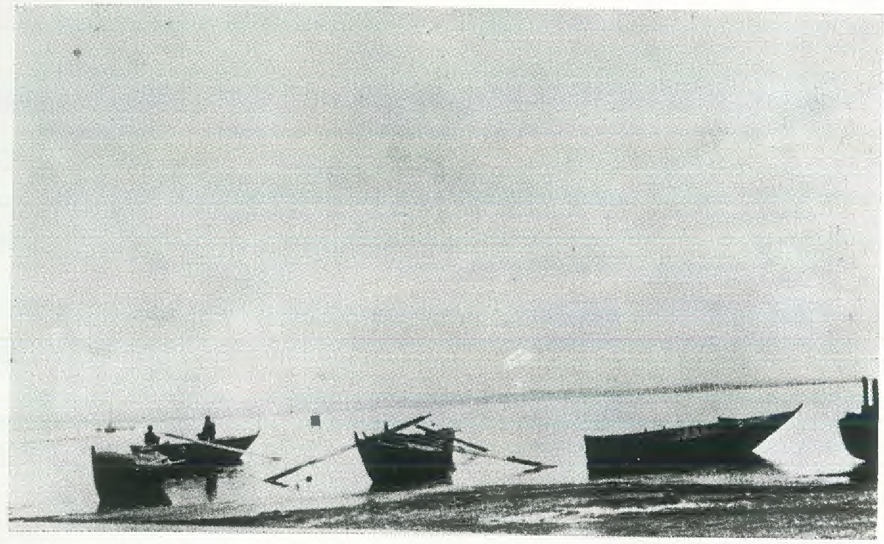

Photo 7. — Fishing boats on lake Qarûn.

Photo 8. — A storm beach on the eastern shore of the gulf of Aqaba at Haqal.

AN OUTLINE OF THE ECONOMIC GEOGRAPHY OF EGYPT

DURING THE MIDDLE AGES (640-1517 A.D.)

BY

ABDEL FATTAH WEHEBA

This article attempts to provide the basis for a reconstruction of the economic geography of Egypt during the Middle Ages (640-1517 A. D.). The endeavour is, however, an ambitious one since it requires compressing the economic geography of nearly nine centuries into such a small space. In so doing, sweeping generalization cannot be avoided.

Evidently, medieval Arab sources must loom large in this study. Yet the fact remains that the available material is so fragmentary to permit of an adequate treatment. More serious, in this respect, is that most of what is available belongs to the later part of the Middle Ages, during which Arabic culture took root, and Egypt became a leading power in the Middle East. Consequently, the balance is necessarily tipped in favour of the late Middle Ages.

A CHANGING SCENE

No comment is wanting here upon the geographical long-lasting and stable elements of Egypt proper. On this subject, namely the physical background of this riverine habitat, the reader will find a vast literature. Suffice it to make mention of significant changes in the landscape, which had in general adverse economic effects. These were (*a*) the shifting of the main stream at Cairo, (*b*) the decline and even disappearance of some of the Nile branches, (*c*) the spread of waste land in the Nile Delta and the Faiyum province.

(a) *The shifting of the main stream at Cairo.*

Owing to the gradually changing courses of the main stream and its channels we expect nothing but a different picture of the river system of the Arab period. The changes were mainly due to the excessive depositing of silt in the lower reaches of the river and the natural displacements of currents.

Arab sources, of which Makrizi's « al-Khetat» is the most distinguished, discuss the progress of the westward shifting of the Nile course at Cairo [1]. It seems that the change went on steadily but very gradually throughout the Arab epoch. The government looked with anxiety upon this phenomenon as it would result in unexpected hardships with regards to the capital water-supply and would, in the course of time, rob Cairo of much of its economic and strategic importance. Many attempts were, therefore, made by the government to check the progressive shifting of the river in its bed [2]. But in view of the inadequate knowledge of water-control, the steps taken were usually ineffective and in some cases having contrary results.

Thus the natural process went on unchecked; « first islands arose in the river bed, then the water courses, which separated them from the bank, were cut off from the main bed forming closed lakes only filled with water at periods of flood. These lakes, in due course, dried up as a result of excessive evaporation and a continuous accumulation of deposits» [3]. So by the end of the Arab rule (1517 A. D.), there had already emerged a long strip of alluvium (about $^3/_4$ of a mile wide) to the west of the capital (Fig. 1). The land, thus gained from the river, was first of all used for raising tree crops, then finally built on. To-day, some of the modern quarters of Cairo i. e. Garden-City, el-Tawfikia, Bulak, Rawd el Farag, are located on this tract.

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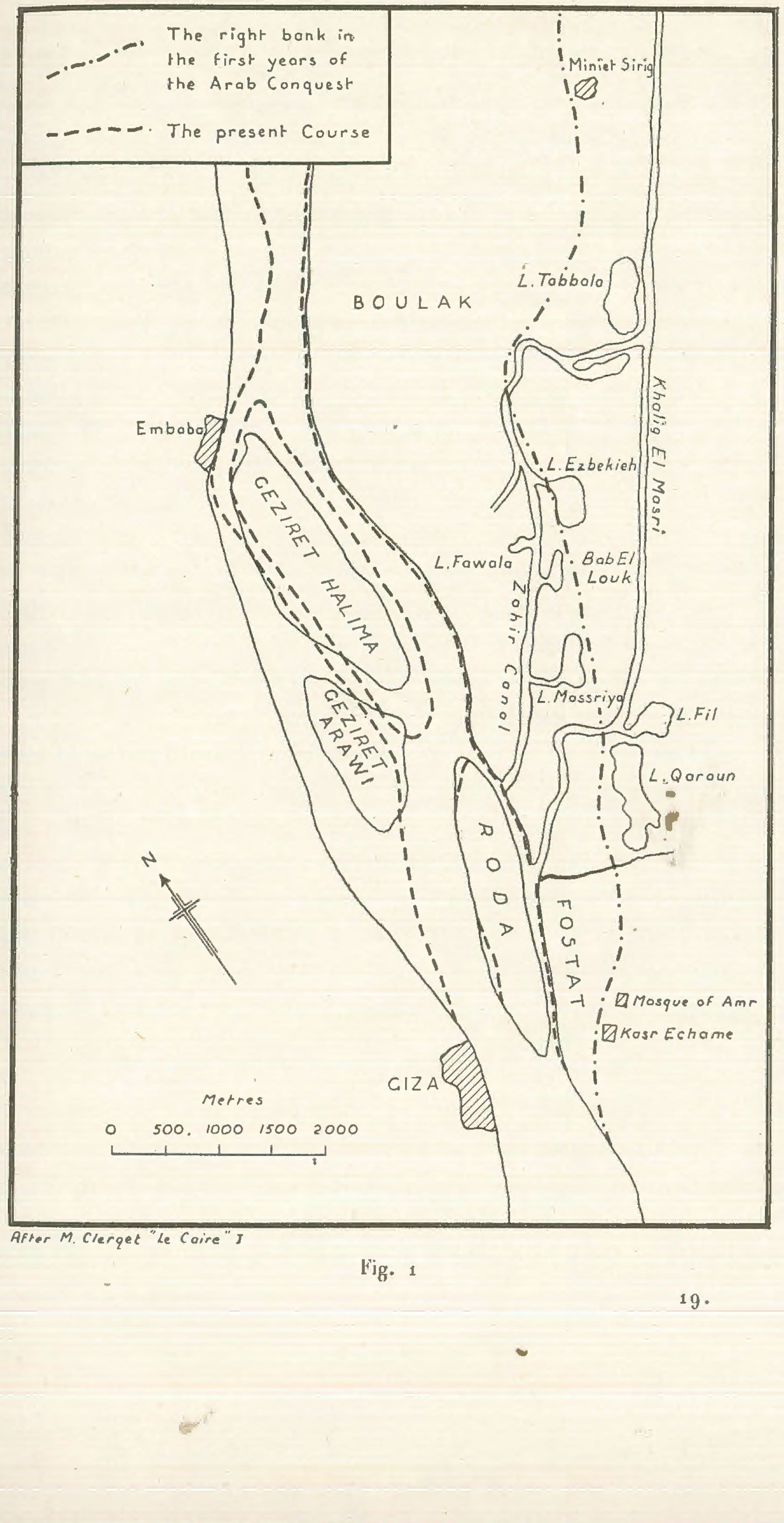
(1) Makrizi : *al-Khetat,* Cairo 1905-1907, Vol. I, p. 343 and Vol. II, p. 154.
(2) *Ibid.,* Vol. III, p. 270. See also Vol. II, pp. 151-153.
(3) Makrizi : *al-Khetat,* Vol. III, p. 32.



After M. Clerget "Le Caire" I

Fig. 1

(b) *Decline of some Nile branches.*

In the Delta the gradual silting up and consequent decline and even disappearance of some of the river channels before the close of the 15th century A. D., undoubtedly influenced the natural distribution of the flood water and was, in part, responsible for the constant change in administrative boundaries. The task of tracing the former channels is not an easy one, owing to the conflicting views of the Arab writers on this point. However, the accompanying map (Fig. 2), is an attempt by A. Guest [1] to show the main lines of the river channels in the 10th and 12th centuries. According to him, the present arms of the river — the Rosetta and Damietta branches —follow almost exactly the same courses as they did in the 12th century. The point of bifurcation at Shatanuf was about three miles further north than it occurs at present. On the other hand, it is believed that the Rosetta branch acquired its present alignment since the tenth century. The apex of the Delta was then at Shatanuf; but precise information beyond this, as to the Damietta branch in the tenth century, is lacking. A third arm of the river which existed in the twelfth century was a channel substantially identical with the present el-Bahr el-Saghir.

The other branches of the Nile, reported by Arab itineraries to have been in existence in the twelfth century, disappeared. At least two of these branches led through lakes to the sea, namely the Alexandria and Tinnis channels. In the territory between the Damietta and Rosetta branches, the disappearing twelfth channels (Fig. 2), follow in many parts of their courses the present artificial canals, though at some points the latter cut across the former lines. In any case, all these channels were navigable waterways and on their banks stood most of the rural settlements in the Delta.

c) *The spread of waste land.*

It is most likely that early occupance of the northern Delta took place in late Dynastic and Ptolemaic times, following a recorded regression

[1] Guest A. : The Delta in the Middle Ages, *J. R. As. S.*, 1912, pp. 941-945.

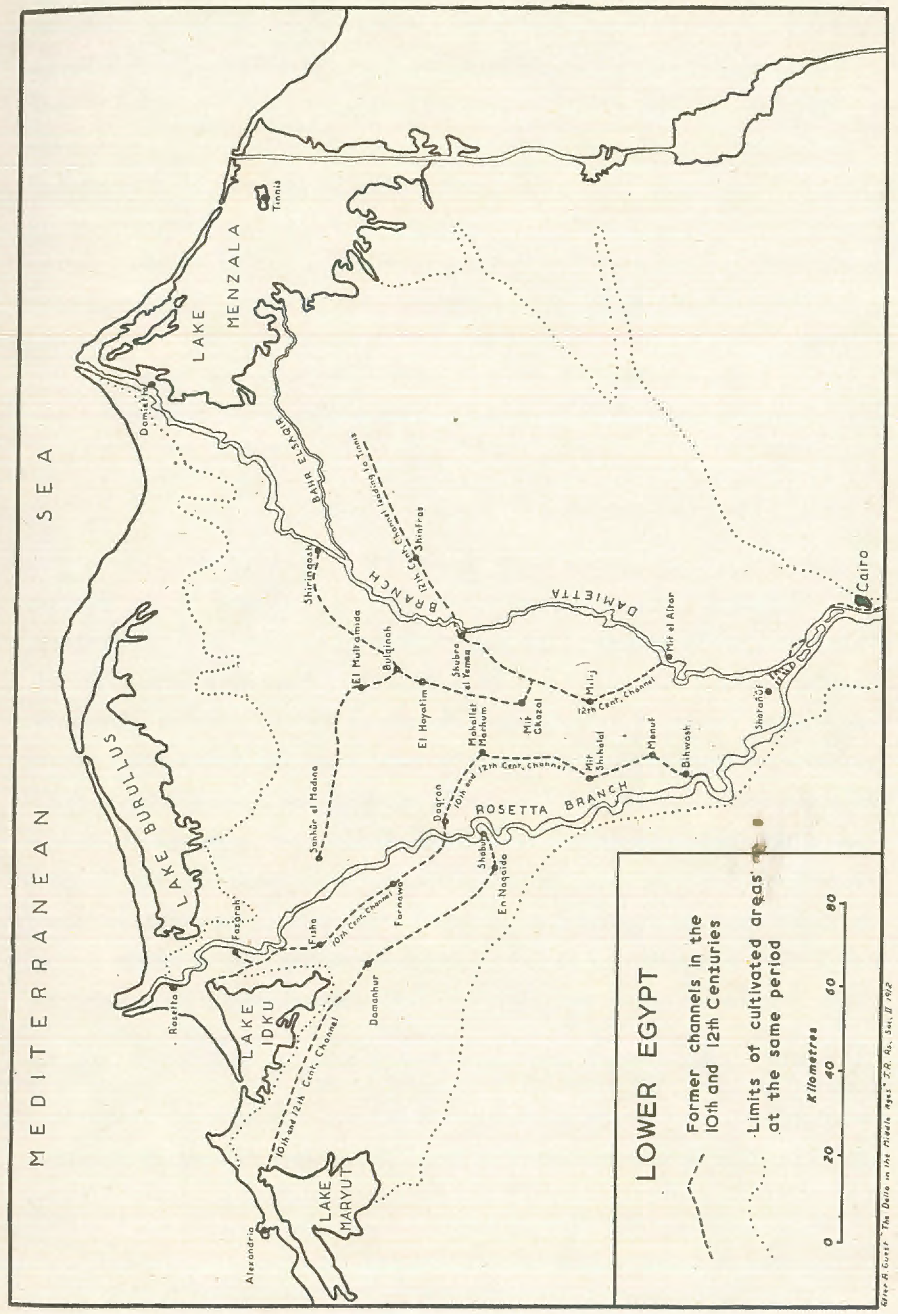


Fig. 2

of the Mediterranean [1]. This incident, is believed to have resulted in a natural marsh drainage, and a northward extension of the Delta [2]. For centuries thereafter, the northern land appeared dotted with villages and green fields. But since the 2nd century A. D., this agricultural land started losing in productivity, giving rise ultimately to waste. We prefer to think that such deterioration was primarily the result of a gradual rise in sea-level, accelerated by negligence of the existing system of canals and embankements. According to Makhzoumi (12th century A. D.) the year 961 A. D., marks the end of agricultural life throughout the tract.

> « Between the neighbourhood of Fakous and Gargir (two towns in the northeast of the Delta) and the lower reaches of the Alexandria canal lies a belt of unproductive land.... This belt was once productive and inhabited.... The year 350 A. H. (961 A. D.) marks the end of prosperity and the advent of devastation » [3].

Unfortunately, and to the great lose of Egypt, the retreat of the arable land southwards continued unchecked. This is evidenced by the location of the northern boundary of the cultivated land early in the 19th century. It ran, a shown on the map (Fig. 3) by Delingat, Damanhur, Itai el-Barud, Shubrakhit, Desuq, Kafr el-Sheikh, Mahala el-Kubra, Sherbin, Mansura, Simbellawin and Belbeis [4]. It may be noted that, for peculiar conditions, three places in the north of the Delta escaped the encroachment of the waste; namely the vicinities of Rosetta, Baltim and Damietta [5].

Archaeological evidence reveals that the prosperity of the Faiyum province was at its highest from the 2nd century B. C. to the 3rd century A. D., after which the province suffered from the encroachment of the desert [6]. In consequence, important Ptolemaic sites (i. e. Bacchias,

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[1] Butzer C. : Environment and human ecology in Egypt, *Bull. Soc. de Géog. Eg.* T. XXXII, 1959, p. 63.

[2] *Ibid.*

[3] Kamal Y. : Monumenta cartographica, *Afr. et Aegy. Epoque Arabe,* Hague 1926, Part 4., p. 892.

[4] Willcocks W. and Craig J. : *Egyptian irrigation,* London 1913, Vol. I, p. 368.

[5] Audebeau M. : Terres du Bas Delta, *Bull. Inst. Eg., Session* 1925-1926.

[6] Hunt G. and Hogarth : *Some Fayum towns and their Papyri,* London 1900, pp. 15-16.

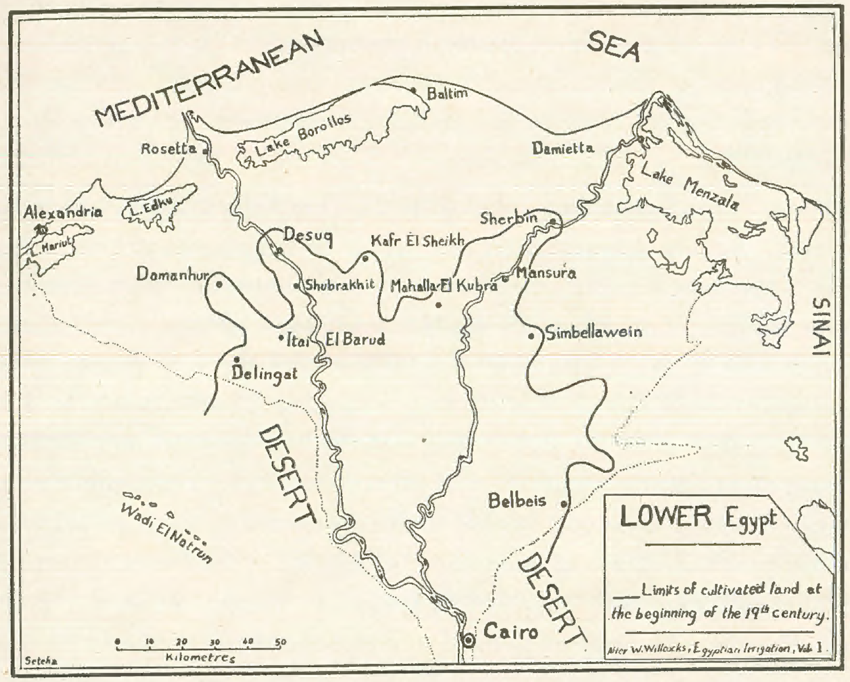

Fig. 3

Philadelphia and Euhemeria) were deserted and agricultural land shrank. On the state of the Faiyum in the Middle Ages, we possess a revealing document, namely the « Kitab Tarikh el-Faiyum» by Abu Osman el-Nabulsi, governor of the province in 1245-1246. Nabulsi deplored the fact that many tracts in the Faiyum had been abandoned in his days owing to failure of water-supplies [1]. He explained that such failure was the result of carelessness and negligence of irrigation-works. There is no doubt that the peculiar dependence of the Faiyum on elaborate methods of irrigation was responsible for the steady diminution of its agricultural land in the days of irresponsible governors [2]. But in no way did the lose in productive land detract from the reputation of the province as the « orchard» of medieval Egypt.

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[1] Nabulsi : *Tarikh el-Faiyum,* Cairo, 1899, p. 17.

[2] This is confirmed in Nabulsi's work, on page 6.

ECONOMIC ACTIVITIES

A. Agriculture.

Irrigation :

Owing to the prevailing dryness in the Nile Valley, agriculture was, as now, entirely dependent on the supply of irrigation-water from the Nile. A system of basin irrigation devised to secure the water demands of winter crops operated remarkably down the centuries until it was supplanted by the system that secured water all the year round. The fundamentals of the old system were embankments and canals, and it was the height of the flood, together with the degree of efficiency of these two elements, that annually determined the area brought into cultivation. As the height of the flood was beyond human control, the principal duty of any government was to make the best use of the flood water by maintaining and improving the existent irrigation system. In so doing the administration found itself obliged to adopt the corvée method.

So vital was the clearing and maintenance of canals that the enlightened administrations were always in struggle against silting up which would, if neglected, block the canal entirely. Makrizi (15th century A.D.) provided a remarkable account of how the restoration of the Alexandria canal in the 14th century brought in its trail prosperity to the country it traversed and the city it supplied.

> « When the restoration of the canal was effected, the inhabitants recultivated stretches of land and constructed water-wheels. It was estimated that more than 100.000 acres were again put to the plough, about 600 elevating machines constructed and 40 settlements appeared. Large merchant ships freighted with goods sailed via this canal to Alexandria, whose population was able to receive their water-supply directly from the canal after being accustomed to stored water drawn up from underground cisterns ... In addition some 1000 fields were restored and people from the neighbouring areas attracted by this sudden prosperity migrated to inhabit what was once desolated unproductive land » [1].

[1] Makrizi : *al-Khetat,* Vol. I, p. 277.

The proper upkeep of the second element of basin irrigation, dykes, was also essential for the effecient distribution of flood water. We hear of a certain office in Cairo established to co-ordinate the maintenance work and fix the contribution required from each village. Sometimes the Sultan himself undertook the organization of labour and appointed princes held responsible with their men for any failure in the embankments during flood.

There is every reason to believe that artificial irrigation devoted mainly to summer crops and orchards was in full swing during the period under discussion. Water-lifting devices such as the water wheel and the pole and bucket elevated water for crops grown along the banks of the river and canals. The water-wheel with the endless rope was most useful in raising underground water to orchards and plots situated away from the waterways. Perhaps the introduction of extravagant crops in water requirements such as rice and sugar cane, and the prosperity of horticulture, testify to the immense contribution of artificial irrigation during the Arab administration.

Field work :

Irrigation was the major operation performed on the farm. Immediately after the basins were emptied, there followed scarcely any tillage operation in most of upper Egypt. After being, scattered, seeds were pressed into the wet soil by means of a trunk of a tree. Further north, in the Faiyum province and in the Delta, the land usually received a ploughing during which seeds were scattered after the plough [1]. Then the land often had a rolling by means of a plank dragged by oxen to press the particles of the soil and secure a protection of earth over the seeds. During the growing season, winter crops did not call for further field work save in the Delta and the Faiyum where crops received from one to two waterings. When the cereal crops and beans reached maturity in the spring, primitive devices such as the threshing machine (Norag) and the wooden fork were used to separate the grains from the chaff.

[1] Ibn Mamati : *Qawanin el-Dawawin,* Cairo 1943, pp. 258-278.

On lands assigned to summer cultivation, field work was rather, strenuous. Apart from lifting-irrigation which called for constant watch and sometimes tremendous efforts, tillage operations varying between ploughing, rolling and hoeing were most requisite. Manuring was also a characteristic practice adopted to offset the fertilizing sediments brought by the Nile. In water-lifting, ploughing and rolling, the peasant made use of cows, oxen and buffaloes. It may be relevant to point out that these animals were bred mainly to labour on the farm and rarely for meat or dairy products.

The Egyptian cultivator in this period, much after his forefathers, followed scrupulously an agricultural calendar that was based on the times of the rise and fall of the river-level. According to this calendar he grew winter crops late in the autumn and harvested them in the late spring before the scorching sun of the summer. Summer crops were sown in the winter and reaped in the late summer. Fixed times for the watering of fruit trees, pruning them and finally collecting their fruits were carefully observed [1].

Winter Crops :

Winter crops were, by far, the most extensive and formed the backbone of the agricultural wealth of Egypt. Wheat, barley, beans, lentils, clover and flax were the important crops of this category. Cereals, wheat and barley, were, however, the most widely grown crops. Together they might have occupied yearly about 50 % of the total cultivated area, the other half being divided between the other winter crops and summer cultivation.

Wheat was cultivated in all parts of Egypt from Aswan to the Mediterranean. Apart from the salty tracts of Lower Egypt and the poor region of southern Upper Egypt, the crop was extensively grown in all the provinces. But the region reputed for the good qualities of its wheat samples, was Middle Upper Egypt, from around Qena downstream, to the head of the Delta [2]. Yakoubi (9th century A. D.) stated that the

[1] Ibn Mamati : *Qawanin el-Dawawin,* Cairo 1943, pp. 234-276.

[2] Kalkashandi : *Subh el-Asha,* Cairo 1938, Vol. I, p. 448.

district of Taha (in Middle Upper Egypt) grew the most esteemed wheat [1]. A later traveller of the 12th century A. D. mentioned that wheat supplies of unusual cleanness were obtained from the district of Manfalout, and shipped annually to the capital [2].

There is sufficient evidence that in Egypt of the Middle Ages the production of barley was second in importance to that of wheat [3]. Its cultivation in the Nile Valley was rather extensive, from the extreme south to the extreme north. Another quite different type of barley cultivation existed in the Maryut region and northern Sinai. Since it depended entirely on occasional winter showers, this cultivation was peculiar to Egypt and assumingly negligible. In terms of quality Egyptian barley held a renown that reached European markets [4]. Then, as now, barley was used as a fodder and a food grain.

Beans in this period held a prominent place among other leguminous plants such as lentil, chick pea and loupin. Precisely speaking, the provinces of Girga, Asyut and Minia have long been reputed for bean cultivation. Bean growing was also practised in the southern districts of the Delta, but in view of the relatively insuitable conditions, the crop was generally not advantageous and of inferior quality. Apart from their value in the feeding of animals, beans made cheap and substantial meals for the Egyptians. On the other hand, Egyptian clover (called «Bersim» by the Arabs) is believed to have come to be the dominant fodder in Egypt since the late Roman period. Not only was «Bersim» grown to meet the need for animal food but also for its fertilizing and restorative properties. It appears that its cultivation was extensive all over the Delta where artificial irrigation was easier and cheaper. But it

[1] Yakoubi : *Kitab el-Buldan,* Leyden 1905, p. 60.

[2] Ibn Jubair : *The travels of Ibn Jubair,* Leyden, 1907, p. 60.

[3] Perhaps the most important documentary evidence in this connection, is the land-tax records of the year 1245 A. D., compiled in Nabulsi's work on the Faiyum province.

[4] This may be inferred, for instance, from the remarks of Geradus Burchadus who visited Egypt in the 12th century A. D. «Egypt, he said, «produced renowned wheat and barley». (Y. Kamal, *Monumenta Cartographica.* Epoque Arabe, 4th part, p. 886).

tended to become less widespread with distance from the apex of the Delta until it disappeared beyond the town of Farchout, situated in the Qena province. Field pea and vetch were the important fodder plants that replaced «Bersim» in the provinces of Qena and Aswan.

In Egypt flax offered the most common fibre in antiquity as well as in the Middle Ages. It supported a flourishing linen industry that was widespread over most of the country. In addition to fibre, flax was also grown for linseed oil that was used for certain domestic purposes. The area devoted to flax was much less extensive if compared with that of any aforementioned crop. In light of the remarks made by the Arab writers and those of the French scholars in the 18th century A. D., flax was raised in the provinces of Asyut, Menia, Beni Suef, Faiyum and Giza and in certain localities in the interior of the Delta [1].

Summer Crops :

So much for winter crops. Summer crops were those grown after the fall of the water level and were more or less independent of the flood water. Because of its costly demands, it was the rich who carried out and supported this type of cultivation. One fundamental fact lies behind summer cultivation : the attempt to overcome the natural handicaps to get more out of the soil.

Summer crops were mainly raised on the banks of the river and canals. These lands had the advantage of an elevating machine that water could be obtained. On suitable low lying land use was made of underground water. Cash summer crops such as sugar cane, rice, indigo, safflower and cotton were the most cared for. It is noticeable that the geographical surroundings of Upper and Lower Egypt decided the scatter of these crops. Sugar cane, for the extraction of sugar, was cultivated in Upper Egypt [2]. Rice, a wet crop, prospered in the north saline tracts of the Delta and in the Faiyum province, where water-supply was available all

(1) IDRISI : *Nuzhat el-Mushtak,* Paris 1836, Vol. I. p. 314.
(2) *Ibid.,* p. 123.

the year round [1]. The two dye plants, indigo and safflower, were restricted to Middle Upper Egypt especially the provinces of Giza and Beni Suef. Cotton culture was limited to the southern part of the Valley, though some scattered patches might have occurred in the Delta and the Faiyum province. In the light of many indications, it may be safe to state that nearly 30 % of the total arable land was annually devoted to this type of cultivation. Undoubtedly, the spread of the newly introduced sugar-cane and rice must have been at the expense of other summer crops as well as winter cultivation.

Trees :

An interesting and promising experiment was carried out to increase the country's agricultural resources and secure the bare needs of timber in times of war with the Crusaders; it was the laying out of acacia and tamarisk plantations in the eleventh century A. D. Two of them were situated on the northern approaches of Cairo while the other seven timber estates were located at intervals in Upper Egypt between Saft Rashin and Qous [2]. Altogether, their total acreage probably did not exceed 40.000 acres [3]. A board was set up to manage these plantations, and it seems that for some time it succeeded in its efforts, and the well-tended groves appreciably relieved the rather monotonous riverine habitat. Then there followed a period of decline (possibly starting in the early 13th century) during which the plantations experienced a gradual clearing, unlawfully done by dishonest wood-traders and feudatories [4]. At the opening of the 14th century nothing was left of these groves and their sites were presumably brought into cultivation. A

(1) MUKADDASI : *Ahsan el-Taqasim,* Leyden 1906, p. 208. See also NABULSI : *Tarikh el-Faiyum,* Cairo 1899, pp. 101-103.
(2) IBN MAMATI : *Qawanin el-Dawawin,* Cairo, 1943, p. 339.
(3) This estimate is based on a preliminary calculation of the total number of acres, the above mentioned localities owned at the time when the plantations existed. The figures are to be found in IBN DUKMAK'S : *Kitab el-Intisar,* Cairo 1898, Vol. V, pp. 8-20.
(4) MAKRIZI : *al-Khetat,* Cairo 1905-1907, Vol. III. p. 309.

secondary source of timber exploited by caliphs and sultans was those tree-hedges enclosing their many and vast orchards [1].

Most evidence confirms that fruit-trees were looked upon as equally profitable as any other soil produce. These trees can be divided into two categories; those outside and those within the orchard. The former were mainly date trees, sycamores and dom-palms. But the date palm was by far the most valuable and the most widely cultivated. Date palm groves seem to have concentrated in the areas now reputed for their vast date production, namely the southernmost part of the Nile valley and the north and east of the Delta [2]. But the dates of Egyptian palms were not on the whole of high quality. «The date trees», remarked Abdellatif of Bagdad (13th century) «are very common in Egypt, but if we compare their fruits with those of the Iraki palms, we find them less sweet and appetizing» [3].

We hear comparatively much about large and magnificent orchards laid out by the ruling classes in the latter part of the Arab administration. Most of these orchards were to be found in the neighbourhood of the capital, in the Faiyum province which, as previously remarked, was termed the «orchard of Egypt» and lastly in the vicinities of important towns, notably Alexandria and Damietta [4]. In these orchards grew the previously acclamatized fruit trees (i. e. pomegranate, peach, fig, apricot, mulberry and vine) side by side with the newly introduced citrus and banana trees. Besides, the orchards abounded in aromatic plants. The great abundance of fruits and the diversity of roses and vegetables struck Nasir Khosru, an eleventh century traveller.

> «I saw in Egypt, remarked N. Khosrau, «at one season roses in three colours, jasmin in two colours, Egyptian lotuses in two colours, myrtles, sweet basils, violets, wall-flowers, fruit of the «nabk» tree,

[1] Makrizi : *al-Khetat,* Cairo 1905-1907, Vol. I, p. 305.
[2] Ibn Dukmak : *Kitab el-Intisar,* Cairo 1898, Vol. V, p. 30.
[3] Abdellatif : *Kitab el-Efada,* Paris 1810, p. 9.
[4] Ibn Dukmak : *Kitab el-Intisar,* Vol. V, p. 48 and pp. 84-89. See also Mukaddasi : *Kitab Ahsan el-Taqasim,* pp. 198-199. Makrizi : *al-Khetat,* Vol. IV, p. 184.

> oranges, lemons, ripe black dates, bananas, unripe and ripe grapes, green figs, almonds, water and sweet melons, pomegranates, aubergines, pulses, chick peas, lettuces and asparagus» [1].

But despite their efforts to bring horticulture to high standard, the Arabs were responsible for the decline of viticulture which was very thriving in the preceding Byzantine period. This was brought about by enforcing a religious ordinance forbidding the drinking and making of grape-wine [2].

B. Industry [3].

Medieval Egypt was not a purely agricultural country; industry, it is inferred, employed a fraction of the population. Cloth manufacture, sugar-making, the extraction of oil, the preparation of plant dyes, ointments and hides, were the chief industries to which agriculture and its subsidiary branches gave rise. A less important category of industries depended on both local and foreign raw materials mostly of other origins; ship-building and paper-making being notable.

Textile Industry :

The very old household linen weaving seems to have continued throughout this epoch side by side with factory weaving. The former industry normally provided the needs of poverty-stricken self-sufficient peasantry population, while the factories produced for moneyed people and for export. In the period between 969 and 1171 A. D. the factory textile industry passed under government control and some state-owned factories were erected to supply the clothing requirements of the Caliph

[1] Khosrau N. : *Sefer Nameh,* Paris 1881, p. 151.
[2] Newyri : *Nihayet el-Arab,* Cairo 1923, Vol. 4, p. 78.
[3] Mining activities in this period were, as expected, of little account. We hear of gold and emeralds being mined by Nubians in the Red Sea Mountains. Salt obtained from the northern lakes supplied the needs of the country. Alum procured from Upper Egypt and the Oases was a state monopoly and usually sold to Greek merchants. Natron like alum was monopolized by the government, its chief mines being at Tarrana in Upper Egypt and at Fakousia in Lower Egypt (Ibn-Mamati, 1943, p. 328, 344).

and his court. It is in this particular phase that the linen textile centres of Tinnis, Damietta and Alexandria produced fabrics of supreme quality. Mukaddasi (11th century A. D.) gives us a glimpse of the organization of this industry under government control.

> « Only when this had been done (namely the placing of an official stamp on the cloth), was the cloth given to a workman, who folded it up, then to another who wrapped it in a packing made of bast, then to a third who did it up in bales and finally to a fourth who tied them up, each of these men had to be paid. The bales were then taken to the harbour, and here also a charge was made and each man put his mark on the bale» [1].

As for cotton, it was grown on a very limited scale, and the produce, it is intimated, was augmented annually by small amounts imported from Syria [2]. We hear nothing of cotton having been woven at home, but we cannot exclude the possibility that it might have been woven by some households residing at important textile producing centres, such as Behnessa (in Upper Egypt), Tinnis, Damietta, Shata and Alexandria [3]. It was only after the extension of cotton cultivation in the 19th century that cotton fabrics began to flood the market and bring a rapid disappearance of linen manufactures.

Wool industry flourished long before the Arab domination. According to the available documents, progress continued during the Middle Ages. The Egyptians, stated Abou Salih (13th century A. D.), «make woollen garments and robes of goat hair ... which are not to be found anywhere in the world except Egypt» [4]. A number of villages and towns in Upper Egypt (such as Behnessa, Akhmim, Asyut, Samalout and Medinat-el-Faiyum) were renowned for their woollen fabrics. But despite the prosperity achieved by wool industry, woollen goods could not claim any popularity over linen manufactures.

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[1] Mukaddasi : *Ahsan el-Taqasim,* p. 213.
[2] Naville F. : Les plantes de jardin en Egypte. *Rev. Arch.,* 1925.
[3] Kalkashandi : *Subh el-Asha,* Vol. IV, p. 9.
[4] Abou Salih : *The churches and monasteries of Egypt,* Oxford 1895, p. 62.

Extraction of Oils and Preparation of dyes, ointments etc. :

Oil extracted from sesame, linseed, safflower seed, lettuce, raddish and turnip was consumed locally. It served for illumination, cooking and supported a small soap industry managed by Greek communities [1]. Plant dyes extracted from indigo (blue colour) and safflower (yellow colour) were widely used in the country and held a place in foreign commerce. Highly esteemed for their medicinal properties were ointments prepared from desert herbs and «balsam» plant [2]. The leather industry concentrated at certain towns in Middle Upper Egypt (especially Asyut) and in the Cairo-Fustat conurbation. Mukaddasi (11th century A. D.) found the Egyptian leather goods manufactured at Fustat « soft and durable» [3]. It is reported that a surplus was exported to neighbouring countries, especially Arabia.

Sugar Manufacture :

The incomplete information in respect of sugar manufacture suggests, nevertheless, a most prosperous industry. In fact it represented one of the few industries introduced and developed by the Arabs in Medieval Egypt. Sugar was, it is intimated, used extravagantly by the ruling class especially during the month of Ramadan [4]. A surplus was, after all, Still available for export. After the fall of the Fatimids in the 12th century, the industry continued to boom under their successors the Ayyubids (1171-1250 A. D.) who spared no effort to increase the production of sugar. Sugar-mills, however, turned out granulated as well as loaf sugar, the latter being mainly for export [5]. Treacle was a by-product of this industry, replacing sugar in many homes. In terms of location,

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[1] Abd el-Latif : *Kitab el-Ifada,* Paris 1810, p. 98.
[2] Makrizi : *al-Khetat,* Vol. I. p. 368.
[3] Mukaddasi : *Ahsan el-Taqasim,* p. 198.
[4] Makrizi : *al-Khetat,* Vol. II, pp. 384-392 and Vol. III, p. 343. See also Kalkashandi : *Subh el-Asha,* Vol. III, pp. 494-525.
[5] Khosrau N. : *Sefer Nameh,* p. 173. See also Heyds W. : *Histoire du Commerce du Levant,* Leipzig 1885, Vol. II, p. 691.

the industry centered in the capital as well as at a number of towns in Upper Egypt, i. e. kift, Baliena, Ikhmim, Asyut, Mallawi, Sinnoris and Naklika [1].

Ship-building :

Ship-building was an established industry long before the Arab conquest. Lacking in timber, Egypt met her requirements from Syria and elsewhere. Egypt, too, was famous for a special kind of hemp admirably adapted for cordage and ships tackle [2]. In the late Middle Ages, a thriving foreign trade required a large amount of shipping [3]. Besides, river boats were built in vast numbers to convey the internal trade. According to historians, the need of Egypt for warships was not so pressing in the early part of the Middle Ages, but later a change in the country's political situation necessitated the building up of a strong navy « with a force of over five thousand seamen » [4]. Imported as well as local timber went into its construction. Documentary evidence points out that Cairo, Alexandria and Damietta were the chief centres of ship-building in medieval Egypt [5].

Paper Making :

It is not clear when the making of paper out of papyrus pith declined, nor are we clear on the causes that led to the total extinction of this plant in Egypt. Some authorities, however, fix the year 650 A. D. as marking the end of this industry in Egypt [6]. Since this date and throughout the Middle Ages paper-making depended on plant fibres. Paper-mills established in the capital and possibly at Alexandria, produced different kinds of paper fetching different prices. Undoubtedly the very

(1) Makrizi : *al-Khetat,* Vol. I, p. 136, 328, 329, 374. See also Kazwini : *Athar el-Belad,* Göttingen, 1848, p. 99.

(2) Butler J. : *The Arab conquest of Egypt,* Oxford 1920, p. 320 —See also Ibn-el Fakih, p. 66.

(3) Khosrau N. : *Sefer Nameh,* p. 153.

(4) Makrizi : *al-Khetat*, Vol. II, p. 193.

(5) *Ibid.,* Vol. II, pp. 194-195 and Vol. I, p. 480.

(6) Arnold T. and Grohman A. : *The Islamic book,* Oxford 1925, p. 32.

flourishing intellectual life of the later Middle Ages gave impetus to the industry.

Crafts :

We may add that crafts also attracted some town-dwellers. In architecture, ceramics and metal working etc., the native craftsmen excelled, and the products of these arts attained a more than local fame. « The periods of greatest achievement were those of the Fatimids, when Cairo was the capital of a western empire, and the early Mamluks, after the sack of Bagdad and the dispersal of the craftsmen of Iraq » [1].

C. Trade.

We are very ill-informed on the state of local trade in this period. However, in the light of scattered hints and after drawing parallels from the present commercial life in Egypt, it may be safe to infer that this trade was carried much after the present day fashion. Before proceeding any further, a very important natural factor that controlled business in Egypt must be born in mind; this was the level of the flood waters. Sufficiently high flood meant a year of abundance and brisk business, that below the critical point (16 cubits) brought in its trail famine, a crippled trade and soaring prices. As the Nile controlled the entire commercial life of Egypt, it has offered, at the same time, a great way of communication.

Local Trade :

In villages modest fairs were held, and in them villagers traded in varieties of grains, vegetables, fruits, live stock, and some home-made manufactures such as mats, baskets and dresses. In towns fairly large markets were rich in local products as well as foreign goods, coming from overseas and across the desert. Indeed the busiest place for the home trade was the capital. The prosperity or stagnance of the whole internal trade was truely reflected in the markets of the metropolis. The city received and redistributed most of the surplus products of the

(1) Glanville S. (ed) : *The legacy of Egypt,* Oxford 1947, p. 367.

provinces. Among the agricultural products we might note grains, pulses, wood and fruits [1]. The tax in kind also brought a wealth of grain that made their way to government granaries.

Foreign Trade :

Medieval Egypt commanded and benefited from the flow of merchandise between East and West and disposed of its surplus products to the markets of the three continents. Commodities coming from the East were discharged at one of the Red Sea ports, i. e. Aidthab, Quseir, Tor and Qulzum, whence they were shifted to the Nile where multitudes of boats transferred them (after a break at Cairo) to one of the Egyptian Mediterranean ports, the most important of which were Alexandria and Damietta [2] (Fig. 4). Wares from Central Africa also reached the Mediterranean partly by way of the Nile and partly by sea and land routes. On the other hand, caravans connected Egypt with the Sudan, North Africa, Syria and Arabia [3]. In this period Cairo supplanted old Alexandria as a redistribution trade centre and a conductor of both local and foreign trade [4].

It must be pointed out here that direct trade between Egypt and Christian Europe reached a deadlock in the first centuries of the Arab rule, as a result of religious prejudice. In those early centuries, jewish merchants, «who spoke Arabic, Persian, Greek, Frank languages, Spanish and Slavonic» functioned as intermediaries between Occident and Orient [5]. Only in the early 13th century did direct trade with Christian Europe become copious [6].

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(1) Makrizi : *al-Khetat,* Vol. I, p. 143, 176, 178, Vol. III. p. 152. See also Zahiri : *Zubdat kahf el-Mamalik,* Paris 1892, p. 622. Ibn Dukmak : *Kitab el-Intisar,* Cairo 1898, Vol. V, p. 48. Khosrau N. : *Sefer Nameh,* p. 151.

(2) Newyri : *Nihyat el-Arab,* Vol. I, p. 354.

(3) Ibn al-Fakih : *Kitab el-Buldan,* Leyden 1883, p. 78. See also Ibn Khurdazebah : *Kitab el-Masalik,* Leyden 1889, 79. Ibn Gafar : *Kitab el-Kharag,* Leyden 1891, 190.

(4) Makrizi : *al-Khetat,* Vol. II, p. 189.

(5) Ibn Khurdazebah : *Kitab el-masalik,* p. 153.

(6) Heyds W. : *Histoire du commerce du Levant au Moyen Age,* Leipzig 1885, Vol. I. p. 51.

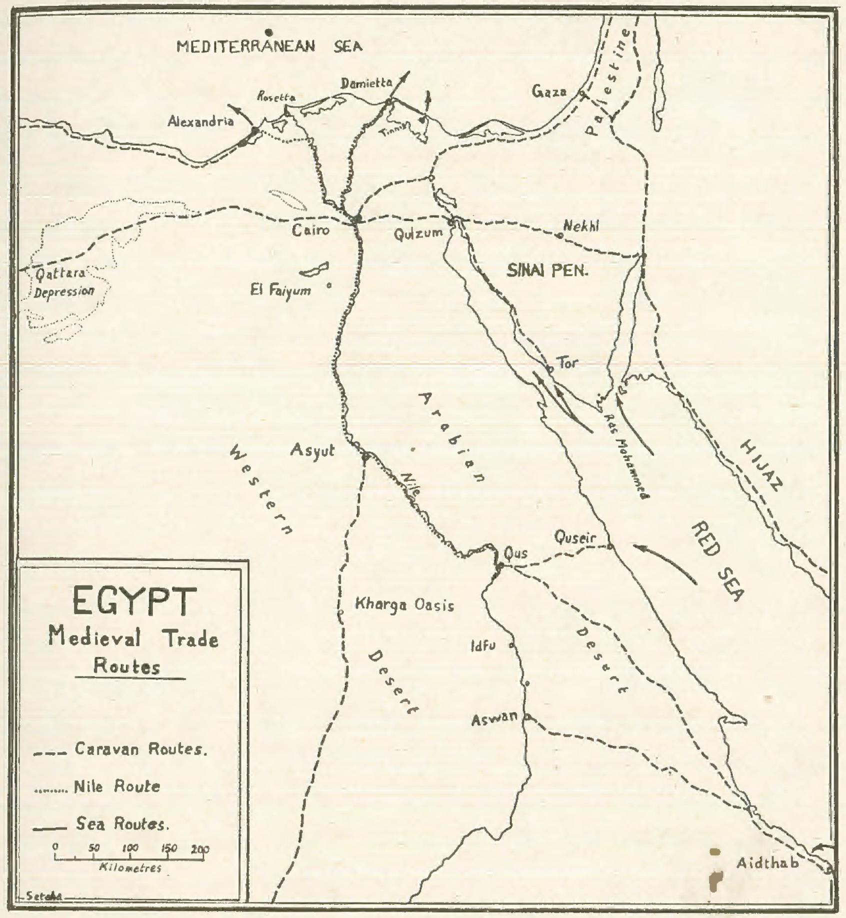

Fig. 4

Apart from Europe, active trade relations linked Egypt and the surrounding Islamic countries since the early centries of the Arab-regime. Egyptian trade relations also reached as far as Central Africa and the Far East. With Cairo as a trade centre, many boats setting out from Alexandria, Damietta and Tinnis, transhipped unknown quantities of Egyptian products i. e. rice, lentils, saffron, indigo, dates, textiles, sugar, leather goods, and salted fish, together with Indian and Central African commodities to the Mediterranean ports [1]. From the Red Sea

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(1) Ibn Jubair : *The travels of Ibn Jubair,* p. 97.

ports of Aidthab, Quseir and Qulzum (Fig. 4) foreign ships freighted with European goods and some home products, made their trips to the other side of the Sea and to India, Indonesia and China [1]. Caravan routes converging on Cairo connected Egypt with both Southeast Asia and Central Africa [2]. The Nile was a great highway during flood and connected Central Africa with the Mediterranean ports of Egypt. In exchange for her products, Egypt received mostly timber, iron, textiles and dried fruits from Europe [3], jewellery, perfumes, spices from the Far East, butter, oil leather fabrics, honey from Syria and North Africa and lastly slaves, cattle, ivory, ostrich feathers, gum arabic from the Sudan [4].

When all is said, the fact remains that in agriculture, industry and trade, medieval Egypt was not so fundamentally different from Egypt of earlier periods.

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[1] Heyds W. : *Histoire du commerce du Levant au Moyen Age,* Vol. I, p. 379.

[2] Shouchair N. : *The history and geography of the Sudan,* Cairo 1903, Vol. II, p. 7. See also Makrizi : *al-Khetat,* Vol I. p. 307.

[3] Depping G. : *Histoire du commerce entre le Levant et l'Europe,* Paris 1830, Vol. I, p. 58.

[4] Masoudi : *Les prairies d'Or et de mines de pierres précieuses,* Paris 1914, Vol. III, chap. XXXIII.

NATIVE PLOUGH IN EGYPT

BY

MOHAMED RIAD

Since millenia the cultivable soils of Egypt is confined to the Delta and the Valley of the Nile. This soil was deposited by the Nile through immemorial times and as a result it is composed, generally speaking, of nearly homogeneous fine particles which attain a mean depth of about 10 meters. The fact that such thickness and homogeneity of the cultivated soils rendering the minimum of soil variations has contributed much to the form and technique of the prevailing plough in Egypt. In fact the Egyptian plough is a simple one which is used to break the soil and not like other contemporary ploughs in Europe and elsewhere, does not invert the soil. This may be due to the aforementioned reason, i. e., the homogeneity of the soil, as much as other physical factors foremost among them are the yearly deposition of new soils through the agency of the flood on the one hand, and the penetration of air through the soil particles during the inter-planting period on the other hand. These factors and others did not necessitate deep ploughing or soil inversion, and as long as these factors remained in control of the type of cultivation in Egypt—which it did all over the history of agriculture in Egypt, due to the system of Basin Irrigation,—the evolution of the Egyptian plough was and is very slow in what concerns the major lines of form and technique. Yet there exist in Egypt at the present time two substantially different types of ploughs which function in similar physical conditions but exist in different regions. Building a co-existence among these two plough types, mixed offshoots arose to balance the picture and to ease the sharpness of plough boundary in the relatively small cultivable area of Egypt. Now we can differentiate at least seven plough types each with a limited geographic area.

GEOGRAPHICAL DISTRIBUTION OF PLOUGH TYPES

The seven mentioned plough types which prevail in Egypt, reproduced in plates 1 to 4, are as follows :

Type I : the split handle, straight beamed type. This type prevails in both Western and Central Delta with the exception of the south-eastern area of Central Delta.

Type II : the single handle, curved beam plough. This type, one of the two basic ploughs in Egypt, prevails in the Eastern Delta roughly south of 31 degree of North Latitudes. It also exists in the south-eastern parts of the Central Delta.

Type III : the single handle, straight beamed plough. This type, being a mixture of both previous types, prevails spatially in the same region type II occupies.

Type IV : the right-angled double handles, straight beamed plough. This type prevails in the northern Provinces of Upper Egypt and reaches southwards as far as the boundary of Minya and Assiut Provinces. Nearly the same type prevails in the North-eastern Delta, roughly in a pocket to the north of Latitude 31, bordered by Lake Manzala to the East and north-East, and by the Damietta branch of the Nile's Delta to the West and north-West.

Type V : the obtuse-angled double handles, straight beamed plough. This type is the second of the two basic plough forms in Egypt, and prevails in southern Upper Egypt.

Type VI : the single handle, straight and short beamed plough. This type is the usual garden type, and has many varieties, some wheeled while others are not wheeled but possess a fork-like extension of the beam, etc... This is extensively used in the Delta, and rarely found in Upper Egypt.

Type VII : the single handle, straight beamed, and wheeled plough. This type is usually used in light soils, especially nearer to the edge of the desert in Eastern Delta.

DESCRIPTION OF THE PLOUGH

Though the aforementioned plough types differ among themselves yet there are some basic characteristics which combine them all. This being explained by the fact that they all labour in nearly the same physical conditions, hence the basic requirements must be similar. In the following lines we will try to describe these basic similarities, leaving aside for the moment their points of differentiations.

1. The Base.—This is the 'foot' of the plough and is composed of a wooden body with a rear butt end and a tapering fore end. Its total length attains some 110 cms. a breast breadth of about 20 cms. and a thickness of about 15 cms. at the butt end. The thickness decreases towards the sharp end of the base owing to the fact that the upper surface is chiselled downwards from the butt end to the sharp point. The base supports the share, the handles, and the beam, and all these are fixed in different manners which will be described below with the exception of the share which is universally fixed to the fore end by a nail in all types.

2. The Share.—This being an iron blade which takes the form of a spear head and a neck. It also varies in size according to the kind of plough and soil. The standard share, usually called « Lisān ʿAṣfūr» —meaning the tongue of a sparrow—has the following dimensions : total length 45 cms, length of neck 15 cms, breatdh of neck 11 cms. wings at broadest 15 cms. The share is fixed on the upper surface of the tappering end of the base by means of a screw or a strong nail, and the share point must protrude some five centimeters ahead of the base point. A garden plough has a smaller share in what concerns the total length; this being only about 30 cms, while that of the plough intended to work on light soils or sandy areas has the same dimensions as the standard share except the breadth of the neck reaches 14 cms. and the breadth of the wings attains some 20 cms. Consequently the garden share is lighter than the standard share while that of the sandy areas is the heaviest of all.

3. Handles and Grip.—The handles are all over Egypt made of wood and attain the height of between 100 and 110 cms. As already mentioned the handle or handles are fixed to the base in different methods which will be explained later. The grip is also a wooden peg either protrouding longitudinally in the case of one handle, or split handle, or a cross beam fixed to the two handles in the double handled types. The handles and the grip serve in the Egyptian ploughs to control the manouvering of the plough and the depth of the ploughing and are handled either by one hand or both hands according to the manner in which the grip is fixed.

4. The Beam.—It is either a straight or curved wooden pole which is attached to the base in different ways, and serves to connect the whole plough with the yoke by inserting a cross peg in a socket holed at the fore end of the beam. The beam attains a length which varies between 300 cms. and 350 cms. and usually has a square cross-section of 10 by 10 cms.

5. The Pin.—This is an iron bar which attains the length of about 50 cms. and a breadth of about 4 cms. This type of pin prevails all over ploughes in Egypt except in type V where we find the pin made of wood. Moreover the iron pin has a set of holes in which a peg is inserted over the beam to prevent it from springing upwards during ploughing, and at the same time controls the angle of the plough.

6. The Yoke.—This is a wooden pole of about 270 cms. in length, which is put on necks of the animals drawing the plough. To fulfil its purpose the yoke has five pegs; one in the middle to which the rope connecting it to the beam is attached, and two pegs at each end of the yoke to which the two ends of the rope which encircles the neck of the animal are tied. Such a yoke is universal all over Egypt except in type VI where the plough is drawn by one animal, thus requiring a small curved yoke to which the single animal is harnessed.

Such are the basic parts of the Egyptian plough and the previous description will be found useful in both understanding the structure of the plough at large, and illuminating in the following comparison.

COMPARATIVE STUDY OF PLOUGH PARTS

1. The Base.—The above mentioned description of the base is well preserved in all types of ploughes in Egypt, but they differ in what concerns the way in which other parts of the plough are mounted on it. In all the types we find that the base is hollowed about its centre to enable to insert the pin but this hole is different in types IV and V because here we find that the pin—though of wood in type V and of iron in type IV—has a wooden supporter attached to it. In type III there is also a kind of supporter which does not function in the same way as in types IV and V, but it has its place next to the pin and thus a special cavity is necessitated near the hollow of the pin. Furthermore the base is bored at about 10 cms. from its butt end to insert the single handle of ploughs belonging to types II, III, VI, and VII. It is also found that the base of type II has another hollow between the hollow of the handle and that of the pin; this is used as a socket to insert the end of the curved beam inside the base. In types I and IV the sides of the base near the butt end are a little bit chiselled to enable to fix the lower ends of the split handle (type I) or the right angled handles (type IV) to the base, but the cavity in both sides is never deep and the lower ends of the handles remain protruding. Again in type V the sides of the base are chiselled deep enough to eliminate the lower ends of the curved handles from sticking out. As the arms of this curved handles are comparatively long, the sides of the base are chiselled all the way through more than a third of the whole length of the base. Moreover some 10 cms. from the rear end of this base the sides are again re-chiselled to the end to enable fixing the beam to the base. Thus we may conclude that the horizontal projection of the base will take a more or less regular form of a broad rear end tappering slowly forwards in all types except in type V where we will find it broadest near the middle and while tappering slowly forewards it also narrows rearwards in two definite steps. This special form of the base of plough type V is a necessary technical accomplishment due to the special form of the wide angled curve of the handles on the one hand and the method by which the beam is fixed to the base on the other hand.

2. The Handles.—There are four types of handles; the split handle in type I, the single handle in types II, III, VI, and VII, the double straight handles of type IV, and the double curved handles of type V. The method of fastening the handles to the base differ in each case. The handles of type I are attached to the base by means of a strong nail to each side. The same method is also applied to type IV. Of the single handle we have already spoken; it is inserted in a socket near the rear end of the base. Concerning type V the arms of the handle are fixed to the sides of the base by means of two iron bands which encircle both arms and the body of the base. Nails are not used in this case, and to make a solid and compact unit of both handles and base in this type wooden pegs are inserted between the two iron bands and the upper surface of the base to tighten the attachment of both components.

There are also some differences as to the angle at which the handles are put to the base and consequently to the share. In the single handle of types II, III, VI, and VII, and in the case of the double handled type IV the angle is nearly a right one. Split handles of type I has an angle of about 100 to 110 degrees, while the angle reaches 120 degrees in type V. It goes without saying that the retreating handles of both types I and V gives the ploughman more ability to manouver the plough from behind and increases his weight or force on the handles and on the plough to regulate the depth of ploughing. The single handled plough may appear at first glance to be technically deficient in this respect; but the structure of such a plough especially that belonging to type II allow for this deficiency by means of a fairly heavy beam which—being curved—is centrally situated on the base, thus giving the plough a more balanced situation which is lacking to a certain extent in types III, VI and VII. In these types there is still some balance as to the pressure of the plough owing to the fact that the beam, though straight, rests on the base at a distance more centrally situated than that of types I and V where we find the end of the beam resting on the rear end of the base. In type IV the handles are but little retreating while the beam rests on the of the base.

3. The Grip.—The form of the grip in all these types fall in two categories, the transversal grip of the double handled ploughs belonging

to types IV and V, and the longtudinal grip of both the single handled plough types II, III, VI, and VII, and of the split handled type No. I. From the point of utility a transversal grip should be handled by both hands and thus precondition that the ploughman should go behind the plough. This is indeed the case in type V, but because the handles of type IV are not retreating rearwards it became awkward for the ploughman to handle the plough from behind, and it is usual in this case that he walkes, beside the plough griping it by his right hand. This way of handling the grip is also usual in the cases of the longtudinal grip of all other types. The longtudinal grip differ in form and length in the single handle types than that of the split handle plough. In the last named the grip is a small wooden peg inserted in the upper part of the handle from behind. This peg is so small that it deserves its arabic appellation « ʿAsfura » which means a sparrow or a little bird. In fact the ploughman in this type does not use this small grip and instead control the plough by the upper end of the handle. The grip in the case of single handled ploughs is usually a larger wooden peg which is inserted in a socket in the handles and protrudes from both sides of the handle. Thus the grip here serves to handle the whole plough.

4. The Share.—All the Egyptian ploughs use the varieties of shares already described above except the share of plough type No. V. Here the share has no wings or neck but take a regular form with a butt end in the rear and a sharp point on the foreward end.

5. The Beam.—We have already detected two kinds of beams in the Egyptian plough, namely the more commonly dispersed straight beam on the one hand and the curved beam which only appears in plough type II on the other hand.

The straight beam differ from one type plough to the other in many respects. In type VI it is to be noted that the beam is considerably short, and a cross pole is fixed to its extremity to enable either a double rope, double longtudinal wooden extension to be fixed at either ends of this cross bar, or a fork-like extension (see plate IV). This is a necessary technical adjustment for the one animal which is assigned to draw such

a plough. The beam of that type is fixed to the base by means of an iron band which encircles the base from underneath while its arms are fixed by nails to the beam. The iron band in this type and likewise in type III and VII is placed comparatively nearer to the middle of the base than to its rear. This being the case because in all these types the beam ends with a cavity in which the single handle of the plough is adjusted, thus the beam does not reach the rear end of the base, and simultaneously this special form of the beam end serves as a support or gives more strength to the way the handle is mounted on the base. In types I and V we find the iron band which fixes the beam to the base is placed on the rear of the base because the beam end penetrate between the split handles of type I and the double handles of type V. The beam of type IV also penetrates between the double handles of the plough, but it is fixed to the base by means of a strong nail or a screw. The curved beam of type II is fixed directly to the base by inserting its end in the special socket bored in the base. To strengthen such an attachment a small peg is drawn in the socket behind the inserted part of the beam.

In type II it is very rare to find a tree branch or a piece of wood which can be carved to make the desired curve and still accomplishes the desired length of the beam. It became obligatory that an extension should be attached to the beam, and that is the cause that plough types of this kind are some times called « Meḫrat be waṣl» meaning a plough with an extension.

The beam extensions which we observe in types IV and V are also obligatory from the technical point of view. As the pin of these two types (iron pin in type IV and a wooden pin in type V) does not regulate the angle of the plough, but serve only to keep the beam from jumping upwards, it became necessary that another device must be made to regulate the plough angle. This is accomplished by the beam extension which is commenly an upward curved piece of wood fixed at its lower end to the end of the beam by a wooden peg. The higher end of the extension is bored at different levels and by inserting a peg to which the rope connecting the plough to the yoke is fixed, the ploughman can change the angle of ploughing by puting the peg in a higher or a

lower hole. One should again stress the fact that though the pin of type IV is made of iron and may have holes like all iron pins of other types, it does not work as a regulator of the plough angle, but the angle is regulated by the beam extension. We can also conclude that a beam extension is technically necessitated by the principles of structure of plough types II, IV, and V, while it does not figure out in other types unless it is added for the sole purpose of completing the length of a much used beam.

6. The Pin.—The pin is used to serve two purposes; as an additional fastener of the beam to the base on the one hand, and to prevent the beam from springing upwards during the ploughing by inserting a peg through the pin over the beam, on the other hand. These two purposes are, universal in all types of the Egyptian plough. But while such functions are preserved in types II, IV and V, another important function is added to the pin in all other types; this being that of regulating the angle of the plough, just refered to above. To fulfil the two purposes of strengthening the beam-base connection and keeping the beam from springing upwards, the pin could be made of wood as it is the case in type V. But to regulate the angle the pin should be made of a different material other than wood. The pin as described above is comparatively short and not so thick as the beam or the yoke; it actually is essentially a sort of a peg. Now if this wooden pin is holed three or four times in the row which we observe in the usual iron pin used in Egypt, the result would be a certain inherent weakness in the wooden pin; because it will not resist the strength of pulling. This simply is the cause why the function of regulating the angle is assigned to the yoke extension in type V, where the wooden pin is used. In type II, the curve of the beam fixes once and for all the angle of the plough, and the pin of this type could easily be made of wood. But using an iron pin in type II is definitely an evidence of cultural adaptation owing to the fact that the area in which this type prevails uses an iron pin. In the case of type IV the iron pin is useless as to the function of regulating the angle of the plough, and its existance is also an evidence of cultural influences.

To relieve the animals from a part of the burden of carrying the whole weight of the yoke and beam, and to keep the beam from falling downwards,

a wooden supporter is put next to the pin. This is naturally not the case in type II where the curve of the beam keeps it standing upwards. In type I this supporter is also lacking.

GEOGRAPHICAL REGIONS AND INTERRELATIONS FROM PHILOLOGICAL EVIDENCES

It is obvious from both the list of appellations of different parts of the plough and maps on figures 1 and 2, that certain differences in naming the parts of the plough do exist in Egypt. These differences, apart from their importance to the study of dialects in Egypt, reveal some definite geographic regions the boundaries of which are supported by well known cultural elements and historical facts. If these regions —which are detected from the study of plough—are not totaly new, there is no doubt that their existence is reinforced by new evidences.

Region One: The Delta. The homogeneity of terminology in the Delta is striking. It is only on maps (c) and (d) of fig. 1 that we find a certain specialization in naming the handle and beam of the plough in Eastern Delta. This area is the domain where plough types II, III, VI and VII prevail. The philological differentiation in this respect is deeply rooted in the technicalities of these plough types; they are all single handled, hence these handles deserve the name of « Romḥ » = spear in contradistinction to « Riesh » = feathers which is applied to the split handle of type I. Because the beam of type II is curved, hence the term Ous = a bow or a curve. Though plough types III, VI and VII possess a straight beam, they are nevertheless called Ous. This is a fact which undeniably point that type II is of older age in the area, and furthermore gives an evidence that all these types are but off shoots of this type adjusted to the cultural milieu of Egypt as a whole (where the straight beam prevail); the beam changed but the old name persisted.

It is also observed that some appellations in the Delta do not belong to any arabic origin, but are derivations from the Greek or the Latin languages. Thus Winkler think that « Balanga » (= the pin of the plough)

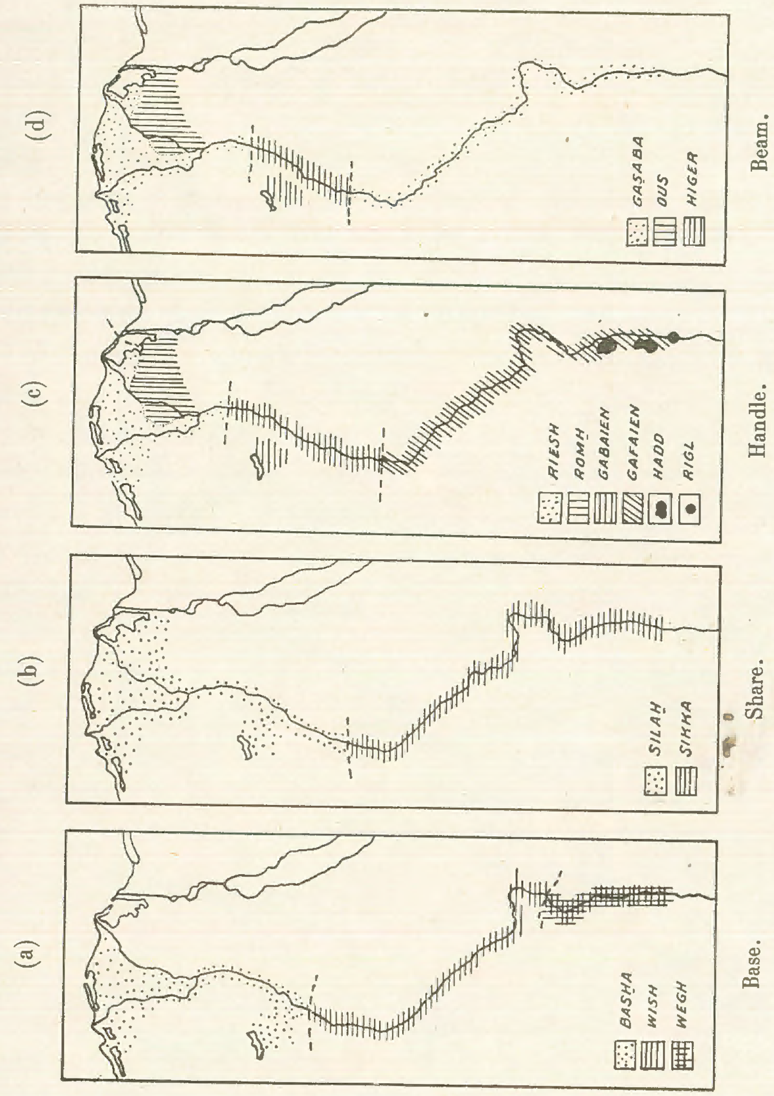
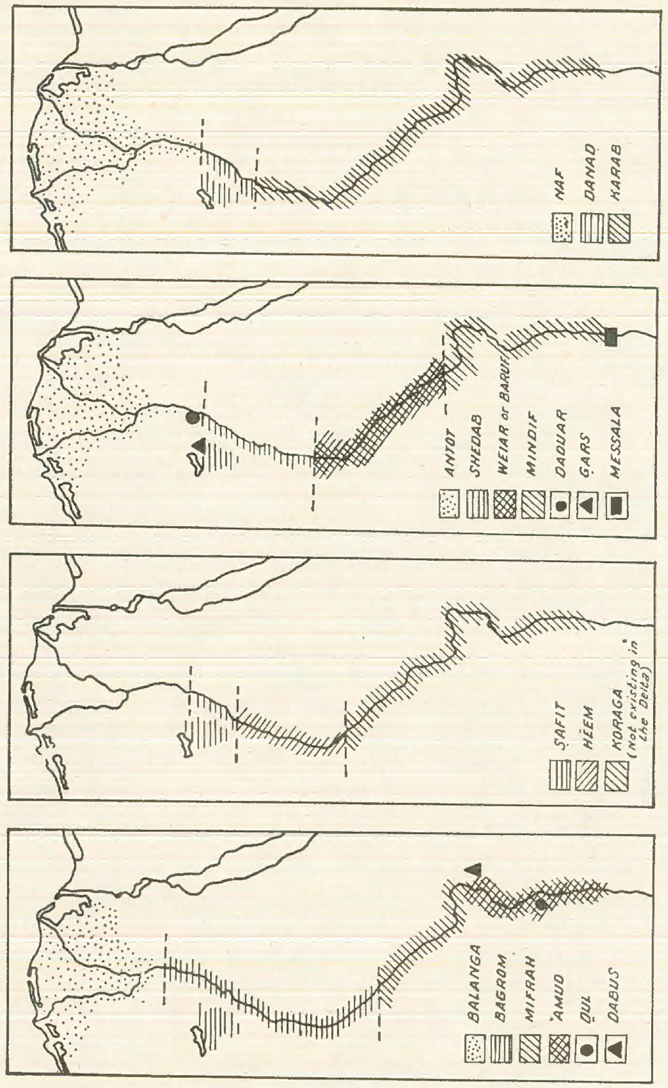


Fig. 1. Appellations of Plough Parts.



(a) Pin. (b) Beam Extension. (c) Cross Peg of Beam. (d) Yoke.

Fig. 2. Appellations of Plough Parts.

point to the Italian word Bilancia [1]. In this way could we seek the origin of the term « Bazḫa» (= the base of the plough) to such origins? In addition to these foreign terms there are arabic names, e. g., « Silaḫ» = blade or share, « Riesh» = feathers, « Romḫ» = spear, while the words « Antot» and « Naf» may belong to the Coptic or ultimately to the Egyptian languages. In this way we may see that the Delta, though homogeneous, reveal three segmented linguistic and cultural layers; the Egyptian, the Greco-Roman, and the Arabic. This conclusion, supported by historical records, has its reasoning in the geographical situation of the Delta as the northern limits of the Egyptian Nile Valley, as the area facing the Mediterranean, and lastly as the area exposed to Arabia.

If the Delta is established as one region, we can further divide it in two sub-regions. Leaning on the arguments stated above, the Eastern Delta would stand alone as a sub-region, while the other parts of the Delta would constitute the second sub-region. There is no part of the Delta other than its East which received so many human and cultural elements from the Middle-East and Arabia and it happens that that part, in what concerns the plough, is remarkably different in terminology and technique. This area, where type II is at home, did not only account for the several offshoots of plough forms (types III, VI ,VII) but also affected the manner in which the ploughman controls his plough. All over the Delta and Middle Egypt the ploughman marches beside his plough where a split handle or a double handle is used. This, as Winkler rightly pointed out [2] is due to the influence of plough Type II, where the ploughman always walk to the left of the plough. In the same source, Winkler claims that this habit of going beside the plough in itself is an evidence of the prior spread of plough II all over the Delta and Middle Egypt [3]. But we must not build a whole theory upon one factor. It is true, as we shall see below, that a curved beamed plough was discovered in Fayum dating to the Roman Period, but this plough was not single

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[1] Winkler, H. A., 1936, p. 162.
[2] Winkler, 1936, pp. 148, 150.
[3] Winkler, 1936, pp. 150, 163.

handled. What is more is that the double handles of this Roman plough reared backwards in as much an angle as that observed in contemporary plough type V. What seems probable here is that plough type IV is directed by the ploughman in the same way as plough II only because the handles are not retreating backwards—hence it would be difficult posture for the ploughman to lean forward behind the ploughand all the time keeping a good distance between himself and the plough, lest his feet should run in the rear of the base. The proper question would be why the handles of this type took a right angle instead of the obtuse angle of type V? One seems to infer this new adjustment of the handles to influences from type II. This, however, does not need the pre-existance of type II in Middle Egypt, because influences can take many channels other than a prior existance.

Region Two : Upper Egypt. This region extends from Aswan in the south to approximately Minya in the North. This region represent the counterpart of the first one, and here we find a deep homogeneity represented by identity and similarity of techniques. Fine dialectal differences are present, e. g., « Wish » and « Wegh » or « Wijh » = face (for the base of the plough), and « Gabaien » or « Gafaien » (for the handles). Identity is attained in naming the essential parts of the handle : « Wish » for the base, « Sikka » for the share, « Gabaien » for the handles, « Gasaba » for the beam, « Koraga » for the beam extension, and « Karab » for the yoke.

Within this region one can find two sub-regions, namely to the North and South of the Nile bend at Qena. The southern sub-region is full of manifestations apparently very old. This may be due to the fact that this area is the southern most of cultivable Egypt, thus representing conservatism at most. We may add to this the existance of influences from Nubia which adjoins the region from the South. We know that the inhabitants of the Island of Baharif, to the north of Aswan, are all Nubians, hence the existance of the special terms which figure on maps (c) of fig. 1 and map (c) of fig. 2. On map (c) fig. 1 we see two localities in Idfu District, west of the Nile, where Hadd is applied to the handles instead of Gafaien. These two localities—

Kelh and Benban—were given this terminology by Winkler [1]. As we have made investigations in the area between these localities (several villages were studied; Abu Ennasr, Abu Ibny, and Rikabi, all of which are put under the cumulative name of Ramadi South in our list) we are led to the conclusion that Winkler must have misunderstood his interpreter in one way or the other. Nevertheless we have specialized a different colouring for both localities on the map pending further research. The most characterising elements in the southern sub-region are the common usage of « Wegh » and « Wijh », for the base, « ʿAmud » instead of, « Miftah » for the pin, and « Mindef » instead of « Weiar » or « Baruf » for the cross peg of the beam extension. This area is furthermore characterised by the overall usage of plough type V. The Northern sub-region is not so valid in its uniting characters, and is more exposed to influences from the North.

Region Three : Middle Egypt. This region includes Giza, Beni Suef, Fayum and Minya provinces. Region of weakness may safely be applied to this area; a glance at the maps on figs. 1 and 2 would suffice to convey this quality to the reader. It sometimes represent a satellite of the Delta cultural region, and in other times it is attached to Upper Egypt. Such a state of affairs can be readily seen from maps (a), (b), and (c) of fig. 1. But this, situation does not include all the region, and one can easily divide it to three sub-regions : Giza Province in general present an increasing influence from the Delta, Minya Province present the other extremity; the Upper Egyptian region knocks always at the door, and lastly the intermediary area of Fayum and Beni Suef which in reality represent in more than one way symptoms of independence symbolised in the peculiarities of its terminology. Here we have « Ḫigr » for beam, « Bagrom » for pin, « Ṣaffit » for the beam extension, « Shaddab » for the cross peg of the beam extension, and « Ḍanaḍ » for the yoke.

Although type IV prevails in this region at large, the different appellations suggest to a philologist the deeper study of such word origins,

[1] Winkler, 1936, p. 153.

either in the Fayum Coptic or with a mixture of Greek origins, for we know that Fayum was once one of the important centers of the Greek Ptolomies.

HISTORICAL EVOLUTION OF THE EGYPTIAN PLOUGH

It is a well established fact that the first recorded form of plough is found on the monuments of Ancient Egypt. Many drawings from the Old and the New Kingdoms of Ancient Egypt can give us a picture relevant to question of the evolution of the plough. There is also a coloured wooden figure of the plough which belong to the 11th or the 12th dynasty kept in the British Museum, and many original ploughs were found near Fayum which belong to the Greek and Roman periods of the history of Egypt, and which are kept in the different Museums of the world, e. g. Cairo and Berlin. All these examples of the plough covering a very long time span can be used as a sound basis for the study of the history of the present Egyptian plough, if we add to it the description of the plough in the 18th century A. D., recorded by Norden[1], and by the scientists of the French Expedition to Egypt[2].

In an unpublished report in the Agricultural Museum of Cairo, a short note is written on the subject of the ancient Egyptian plough. Extracts from the note runs as follows :

> « The ancient Egyptian traditions alledge that the Egyptians are indebted to Osiris, God of Plants in the Egyptian Panthaeon, for the knowledge of the plough. Evidences from early drawings proove that the plough in its original form was worked only by man, and it was only drawn by oxen in the drawings of Meidum, i.e., begining from the third Dynasty. In that form the plough had only one wooden share for ploughing the soft soils; and had a double wooden share covered by a sheet of bronze to plough harder soils.... The plough was called in the Egyptian language SIKKA. »

[1] See references under Norden.
[2] See references under Girard.

In this note it is interesting to see that before the third Dynasty (the beginning of this Dynasty is attributed by Erman to be about 2900 B.-C.)[1] the Egyptians used hoes to break the soil, or at least that is what one can understand from the phrase « the plough in its original form was worked only by man». Drawings of hoes used to break the soil came to us from the remains of the first Dynasty[2]. The plough in its early form, and throughout the Old Kingdom, was composed of a wooden share to which two short handles were fixed from the rear end of the share, while a long beam was fixed to it from the center. The beam ended with a yoke which was at that time attached to the horns of the drawing oxen. In the Middle Kingdom there was no development to this plough, but

> « ... in the New Kingdom we see that the handles became longer, and hand grips were added to the handles. We also see that the yoke was replaced by another type which is not attached to the horns, but which rests on neck of the animal ... this method was taken over from the method of saddling the horse... »[3].

Of special interest in the note of the Agricultural Museum of Cairo cited above, is the appellation of the plough in Ancient Egyptian. Sikka as the name of the plough was conserved till now in Arabic Egyptian, and is used to denote the share of the plough in Upper Egypt[4]. Sikka as the name of the plough in Ancient Egypt may have been supplemented by or was used along with another name :

> « ... The name of a plough was HEBI; ploughed land appears to have been ART, a word still traced in the Arabic ḪART... »[5].

Wilkinson states that the Ancient Egyptians as observed by Diodorus, used hoes extensevely, but on occasions used light ploughs which traced slight furrows, while other peasants followed the plough with hoes to

[1] Erman, p. 26.
[2] Erman, p. 496, footnote 4.
[3] Erman, pp. 496-497. Also see plate 8 of this article.
[4] See list of appellations given in this article.
[5] Wilkinson, Vol. II, p. 393.

break the tenacious soil. He continues to describe the plough in Ancient Egypt at large as follows :

> « The ancient plough was entirely of wood and of a very simple form like that still used in Egypt. It consisted of a share, two handles; and the pole or the beam; which last was inserted into the lower end of the stilt, or the base of the handles, and was strengthened by a rope connecting it with the heel. It had no coulter, nor were wheels applied to any Egyptian plough : but it is probable that the point was shod with a metal sock, either of bronze or iron. It was drawn by two oxen; and the ploughman guided and drove them with a long goad, without the assistance of reins which were used by the modern Egyptians. He was sometimes accompanied by another man, who drove the animals, while he managed the two handles of the plough; and sometimes the whip was substituted for the more usual goad. The mode of yoking the beasts was exceedingly simple. Across the extremity of the pole a wooden yoke or cross-bar, about fifty-five inches or five feet in length was fastened by a strap ... At either end of the yoke was a flat or slightly concave projection, of a semi circular form, which rested on a pad placed upon the withers of the animal, and through a hole on either side it passed a long thong for suspending the shoulder pieces, which form the collar. These were two wooden bars, forked at about half either length, paded so as to protect the shoulders from the friction ... » [1].

It is in the Greek and Roman Periods in Egypt that we see another development over the plough of the New Kingdom. Indeed we find in the two types whose sketches are reproduced on plate 6, the prototypes of some of the present ploughs in Egypt. The plough which was found in Darb Gerza (Plate 6 b) the origin of which is kept in the museum of Berlin, present us with a wooden share and base much similar to the base of the above described plough type V; the sides of the base are chiselled in two steps, one to adjust the handles, and the other to fix the beam. The only difference which may be observed in the method of fixing the handles is that it may have been fixed by nails and not with bands like type V. It is also to be noted that the beam was holed at its rear end to enable to

[1] Wilkinson, Vol. II, p. 390-393.

insert the rear of the base through it, and a nail may have been used in the projecting part of the rear of the base to prevent the beam from sliding out. This much complicated method was substituted by the simpler method of attaching the beam to the base by means of iron bands used now in type V. The beam here is the usual straight beam used in much of plough varieties in Egypt, but in this prototype there is no pin. Instead and in place of the pin socket in the contemporary ploughs, there are two parallel holes in the base, and a rope end is passed in one of these holes then reappears from underneath in the other hole, then passed over to be wind on the beam. In this way it is certain that the angle of the plough never changed unless the rope was changed. On the fore part of the base there are no traces of nailing a metal share to it, but this does not exclude the possibility that the metal share was adjusted to the base not by nails but by bending the edges of the metal round the sides of the base. This may be proved by the various metal shares—especially of iron—which belong to the Greco-Roman period, and whose origin are kept in Berlin.

The plough which was discovered in a house at Harit in Fayum (plate 6 a), and which belong to the Roman period, is kept in the Egyptian Museum in Cairo. This type gives up a combination of both contemporary types II and V, as it is clearly exemplified by the presence of a curved beam, and projecting double handles. The very characteristics of the curved beam are represented here : the beam extension which is permanently fixed here with palm fibers, and the pin which supports the beam is made of wood and attached to the beam, not through inserting in a socket, but by binding it to the beam by a rope, probably of palm fibers too. The beam, neverthless, is additionally fixed by a method which is not found in type II, but by a method retained in the southern tip of Upper Egypt, and in an altered method in Tripoli. This being a rope connecting it to the handles as it is clearly seen in the sketch. The handles are projecting rearwards, and fixed to the base by nails, though another fastner, a rope, tightens them to the base. The grip is lacking in this plough, and the cross bar which figures in the sketch between the two handles may have strengthened the handles, rather than functioned as a grip.

Baumann, agree to the fact mentioned above, namely that the development of the plough was sharpest with the begining of the Greek and Roman Periods, and describes another form the Egyptian plough from the late period, whose origin is kept in Berlin Museum in the following lines :

> « Wichtig aber ist, dass auch der altägyptische Pflug zu diesem Typus gehört, wenn er auch durch seine Doppelsterzigkeit äusserlich etwas anders erscheint. ... Durch alle Epochen bis zur ptolemäischen Zeit blieb der Pflug mit wenig Änderungen sehr ähnlich... Das in Berlin befindliche Fundstück aus der Gräberstadt im westlichen Theben zeigt eine starke Knickung der Sterzen. Hier mündet auch der Grindel ein. ... Dieser altägyptsche Pflug hat im modernen Ägypten seine direkte Fortsetzung gefunden in den hier auftretenden zweisterzigen Pflügen, die allerdings schon wesentlich komplizierter erscheinen. Hier zeichnet sich eine richtige, von der Sterze getrennte Sohle ab, ohne dass aber in den meisten Fällen der Charakter des alten Spaten-Pflugs verloren geht» [1].

It is clear from this quotation that Baumann holds the opinion that though the Egyptian plough has undergone several changes from early dynastic period till the present time, still it holds to its basic spade-like character. This opinion is not only Baumann's, but we also find similar opinion in Winkler [2] and both of them based their conclusions on the extensive studies of Leser [3]. And it is a fact that though the different types of the Egyptian plough may be so complicated in their structure, yet they function on the same principles of a hoe. But we should be aware of the fact that pushing this material similarity far to the realm of culture would lead to much misunderstanding. Using animals in this plough is in itself an evidence of the cultural differences between hoe and plough cultivation, not to mention other differences in techniques of ploughing, production, of crops, and the many other social implications.

Not much description of ploughs in Egypt occur after the Christian Era, and it appear that slow variations took place during this long

[1] Baumann, p. 313.
[2] See references under Winkler.
[3] See references under Leser.

period ; variations which took place due to cultural influences encroushing upon Egypt, but while accepting such influences, we are inclined to think that from the Greco-Roman Period onwards, the forerunners of the Egyptian ploughs were fixed, and throughout two millenia, mixture, selection and adaptation played their role in founding the existing plough types. We cannot ascertain any date for the different existing types, but we may say that they do existed in Egypt in a form very near to its present form since at least three centuries. This may find a support in the drawing of the plough by Norden [1] who flourished in the 18th century, and visited Egypt around the middle of that century. It can be also attested by the drawings and description of the Egyptian plough by the scientists of the French Expedition which took place late in the 18th century.

Norden drew a plough in the village Gamase in Upper Egypt, and from the sketch of Norden one can see that plough belong to type IV of the northern part of Upper Egypt. The base may be larger than in reality, and the beam is fixed to the base by a rope instead of the usual nail. The beam extension is present, but not curved upwards like the present extension in both types of Upper Egypt. The whole drawing seems to be more or less stylish in some points, though it gives a good idea about the form of the plough at that time.

The plough drawn by the French in « Description de l'Egypte» [2] is said to belong to lower Egypt (the Delta) and around Cairo. In his comment on the drawing, Girard states :

> « Nous dirons seulement que celle (charrue) est particulièrement en usage dans la basse Egypte est aux environs du Kaire : celle de la partie méridionale du Sa'yd est beaucoup plus légère et beaucoup plus grossièrement travaillée.
>
> Pour se former une idée de cette dernière, il suffit de concevoir deux pièces de bois d'un mètre de haut, coudées naturellement à leur extrémité inférieure sous un angle de cent degrés environ. Ces deux pièces, ... sont retenues fixement, à un décimètre de distance l'une de l'autre, par deux chevilles ; l'une a quatre décimètres

[1] Norden, pp. 54-55, and plate LVI.
[2] See references under Girard.

> et l'autre à un mètre au-dessus du même coude. Cette dernière cheville les traverse toutes deux, et présente extérieurement deux poignées par lesquelles on peut la saisir» [1].

The assumption that such a plough may be found around Cairo may be right. Furthermore it is implied that this type prevails in middle Egypt, because Girard specialised another plough form for the southern part of Upper Egypt. This plough belong, in our classification, to type IV. If we remember the geographical distribution of plough types, type IV also exist in a pocket between Damietta branch and lake Manzala, but other parts of the Delta belong to different ploughs. Therefore the generalisation of Girard as to the presence of this type all over the Delta is erroneous. Furthermore, making the double handles of the southern Upper Egyptian plough, is not as simple as the description of Girard may convey to the reader. It is rare to find two pieces of tree branches which have the same angle, and as we have seen one of these ploughs in process of making in the desert edge of Luxer district and in the desert edge of Ramadi South—areas culturally poor by the mere facts of there geographical locations and isolations—we are inclined to think that working out the desired angles of such handles needs a good deel of traditional labour and workmanship. Yet complicated techniques are evidences of conservatism rather than progress, hence we can assign older age to ploughs belonging to type V, than for example those of type IV.

This discussion leads us to the crucial question : How did the present types evolved into their different forms?

We have already stated that plough types of the Greek and the Roman periods which we have already described, formed the prototypes of the present ploughs in Egypt. They combined the curved beam, and the double handles in one form or the other. In our classification of plough types we have refered to two basic types, namely the curved beamed type, and the double handled type. Each of these types has his own cultural and geographical region : the first type reigns in the Eastern Delta, while the second type occupies the southern parts of Upper Egypt.

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[1] Girard, Vol. XVII, pp. 22-25.

Now the plough of Dynastic Egypt was more or less double handled, and if the discoveries in Upper Egypt or Fayum reveal, even through the Greek and the Roman periods, the constance of double handles, there is then no doubt that such a characteristic in the Egyptian plough is obviously very old. Again if we consider another part of the plough, namely the beam, we find that the straight beam figures out in all ancient findings, until curved beam appears suddenly in the Roman period, side by side with the straight beam. This sudden appearance is only confined to Fayum, no evidence known refer to the appearance of the curved beam in Upper Egypt, but it is highly probable that curved beam appeared also in different parts of the Delta. We must notice that the curved beam of Fayum appeared in connection with a double handled plough—a fact which either indicate that that type of beam originated with the double handled principle, or that it originated in association with the single handled plough. In view of the constant appearance of the curved beam with the single handle, not only in contemporaneous Egypt, but also in Southern Palastine, Tripoli [1], Tunisia [2], and in South Arabia [3], we may conclude that the combination of double handles and curved beam of Roman Fayum represent an adjustment of the curved beam incrusion southwards from the Delta. All this discussion means that the roots of the present type V plough are definitly older than prototype of plough type II.

Leser in his studies of the plough has settled down the problem of the curved beam plough. In his steps followed both Winkler and Baumann. Winkler states :

> «Der Krümelpflug weist nun deutlich nach Griechenland und Italien hinüber, dort ist dieser Pflug seit sehr alter Zeit zu Hause. Wenn wir zur Bezeichnung der Griessäule das romanisch Balanga (= Latienisch oder italienisch Bilancia) finden, dürfen wir vermuten, dass dieses Wort besonders am Mittelmeerpflug, dem Krümelpflug, gehaftet hat» [4].

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[1] See plate 8, drawings of the plough of Palastine and Tripoli based upon information furneshed to me by some palastinian and libyan students in the Faculty of Arts, Ain Shams University, Cairo.

[2] See plate 8 c, after Baumann.

[3] See plate 8 d, drawn upon photograph 37 in Helfritz (see references under Helfritz).

[4] Winkler, p. 163.

We have no doubt that the single handled curved beamed plough belong to the Mediterranean cultural region, and because Egypt, though lying on the coasts of the Mediterranean, represent in its greater part a somewhat isolated area (especially Upper Egypt), it has evolved its plough type according to its needs. Furthermore Egypt in nearly all its Dynastic history was an independent state, and perhaps that helped towards keeping traditional impliments. When the Greek family of the Ptolomies consolidated its rule in Alexandria, Egypt was open now to the influences of the Greek-Mediterranean culture. This still attained its zenith during the Roman occupation of Egypt. From the Roman period onwards Egypt was part and parcel of successive macrocosmos, namely the Roman Empire, the Arabic Empire, and the Turkish Empire. We are sure that so much influences played its part in the development of the Egyptian plough, but these influences did not overcome the two handled plough, which resisted these encroushments and succeeded to remain nearly intact in southern Upper Egypt, and co-existed with the mediterranean single handled plough in the Delta, intact in its isolated pocket in the Praries of Lake Manzala, and in the northern parts of Upper Egypt. It is only in most parts of the Delta which was incessantly under the influence of the Mediterranean, that a compromise between the Egyptian double handle-straight beamed plough and the Mediterranean single curved-straight beamed type, took place in the plough types I and III, i. e., the split handle-straight beamed type, and the single handle-straight beamed type. The characteristics of plough type I gives us every reason to conclude that it leans heavily on the principle of the Egyptian double handled plough, the only compromise is that the handles are united in the upper part, but the projection of the handles was kept to a certain degree, together with the straight beam. Type III inclines more to the Mediterranean plough in keeping the single handle, but the compromise took place in the change of the curved beam to a straight beam.

One can now safely conclude that the evolution of the Egyptian plough took the following periods and events :

1. Throughout Dynastic Egypt the double handled-straight beamed plough persisted all over Egypt. This plough deserve the appellation

of the Egyptian plough due to its archaic age. In its relatively purest form it survive in plough type V.

2. Begining of the Greco-Roman period the Mediterranean plough extended over many parts of the Delta, and the northern part of Upper Egypt including Fayum. But we are certain that it did not exist in its pure form, at least in Fayum, and was adjusted to the double handle principle. In its pure form it persist now in Eastern Delta. This fact may be explained by the everlasting stream of Arab settlers in this part of the Delta—being geographically exposed to Arabia. Plate 8 show us that the Arabs of Palastine, and those of Hadramut use the Mediterranean plough. The same plough is used in the Oasis of Siwa, the coast West of Alexandria, and in Libya and North-west Africa. It is only Western and Central Delta which break through this continuous distribution of the Mediterranean plough. One can conclude that this plough type did not reign over the Delta as a whole, even in the Greco-Roman period. We must not imagine that as soon as it came to Egypt, it expelled the older double handled plough. We should also bear in mind that neither the Greek nor the Romans ploughed the land themselves, but formed a governing aristocracy in Egypt. It is highly probable that this plough type gained sure footing after the Arabic settlement in the Eastern Delta. This is due to the fact that the Arabs settled down and cultivated the land themselves somewhere around the 10th century. Bearing this in mind, however, does not negate the pre-Arab existance of this plough in different parts of the Delta.

3. Plough type IV, which retains most of the characteristics of the type V, was affected but slightly by the Mediterranean plough. This may be prooved by the fact that the handles does not retreat or project rearwards, but are fixed at nearly right angles to the base. This is a special characteristic of the single handle of the Mediterranean plough.

4. Plough type I has been already mentioned.

5. Plough type III, has been also mentioned, but we may add that this type probably represent the newest adaptation of plough types in Egypt.

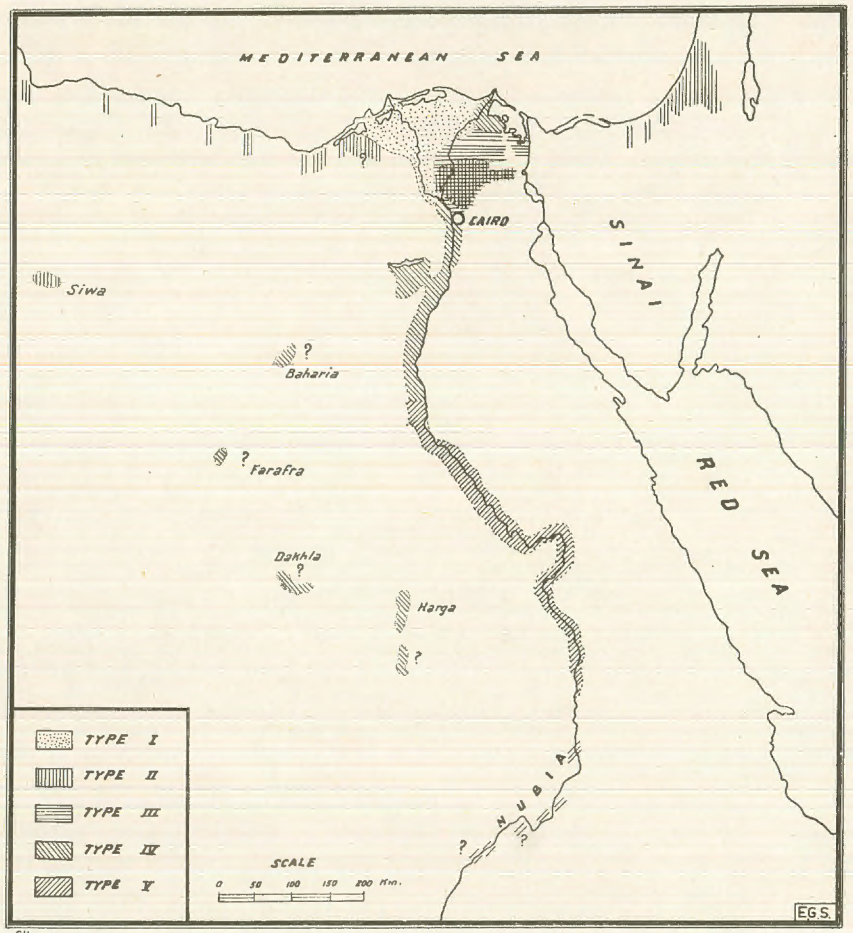

Fig. 3. Regional Distribution of Plough Types in Egypt.

RETROSPECT

The basic plough types just described are not exclusive to Egypt. We have already seen that plough type II has a wide diffusion in North Africa and the Middle East. It may also exist in Tibit, if the drawings reproduced by Ratzel[1] are true. But already in Tibet we see another

[1] Ratzel, Vol. III, p. 384.

plough type, which though straight beamed, has no other similarieties with the straight beamed Type III of Egypt, but had connections to ploughs of East and South-East Asia.

In any case the plough in Africa is confined to the area north of the Sahara, in addition to its isolated existence in the Highlands of Ethiopia. The southern limits of the plough was observed by Ratzel[1], who drew the southern limits from the south of Morroco, includes most of the Sahara, excluding only Mauritania, and ending by Abyssinia. Baumann disagree with Ratzel and states that the plough is to be found only in three regions :

> « ... haben wir aber in Afrika ein fast zusammenhängendes Gebiet das von Marokko über Algerien und Tunis nach Ägypten und Abesssinien führt, wo alte mittelländische und westasiatische pflugkultur beheimatet ist. Die in diesent Raum einschneidenden Lücken (Libyen, Gebiete östlich des mittleren Nil) werden durch das Dazwischentreten nomadisieren der Hirtenvölker erklärt»[2].

Thus Baumann see that the three areas where the plough is to be found in Africa are not connected due to the arrival of the nomads in Libya and Northern Sudan. This may be true but we find a native Mediterranean plough in Tripoli, and in the Oasis of Siwa. This may mean that there is some sort of connection of plough between Egypt in the East and Tunis in the West. Baumann may have been impressed by the reports of different travellers across the Sahara, who did not observe any plough in the Oasis of the Algerian and the Libyan Oasis. But Herzog rightly quotes Rohlfs who stated the existence of the plough in the Egyptian Oasis of Daḫla and Ḫarga :

> « ... dass man sich in einer Oase des pfluges bediente, war mir ganz neu. Weder hatte ich die Anwendung dieses Gerätes in Draa, Tafilet, oder Tuat gefunden, noch in der grossen und ausgedehnten Oas Fessan»[3].

[1] Ratzel, Vol. I, map facing p. 21.
[2] Baumann, p. 310.
[3] Rohlfs, p. 298, in Herzog p. 201.

Herzog again states[1] that the plough is to be found in middle Nubia, and says that an Egyptian governer of Nubia about 1870 tried to persuade the people to use the plough. Though he failed at the begining, the plough, since the introduction of water pumping stations, is now in use in Nubia.

Very important to us is that both the Oasis of Daḫla and Ḫarga use a plough which at least in Ḫarga belong to plough type IV[2], and that Nubia uses also an Egyptian plough. These facts make it clear that the Egyptian Oasis and Nubia are part and parcel of the Egyptian Cultural Region as a whole. The existence of plough type I in Nubia cannot be explained by geographical facts —for as such we would have found plough type V —but can only be explained by the human hazard. If the governor of Nubia happened to be accustomed to Upper Egyptian ploughs the picture would be now different! Trade routes which connect the Oasis with Assyut and Minya Provinces from times immemorial are responsible for the existence of plough type IV in these Oasis.

PROSPECTS

One cannot deal with the plough without a few lines about its future. Egypt, through its long history depended upon agriculture for at least seven thousand years. Until 150 years ago the Egyptian agriculture was used to the method of basin irrigation, and there was generally only one crop. The rest of the year the basins were first under the water of the flood —with its renewal of the fertility— then left to dry, thus enabling the penetration of air and heat in the soil —which add to its strength. It is now the theory that the excellent crop of Basin land in souther Upper Egypt is due to both factors, but more to the resting period of soil —which is called in Egypt season of « Sharaiy or Sharaqy ». This may also be applied to explain the fabulous richness of Egypt through its long history.

(1) Herzog, pp. 205-207. On page 205 there is a photograph of a plough in Middle Nubia, which Herzog on page 206 describes as a one handle plough type. This is not the case, and it is apparent from the photograph that plough belong to the Egyptian type I, i.e., the split handled plough.

(2) Winkler, Plate 35, and text page 148.

Since the application of the system of perennial irrigation 150 years ago, no actual «Sharaiy» is applied to the land, and this is one of the causes of smaller production. We do not mean to hold back the history, because perennial irrigation gives Egypt the possibility of fitting in the economic picture of the world through the cultivation of cash crops together with industrial crops (e. g., cotton and sugar-cane). Egypt cannot afford to retreat to basin irrigation, but on the contrary, all basin land will be converted in the near future to perennial irrigation, after the completion of the High Dam project. Problems of the increasing population of Egypt, added to the land hunger, needs all efforts to make the best out of the situation by increasing the crop area and its output.

Now the plough types which we have described are all of the kind which break the soil and does not invert it. This kind of ploughing only makes superficial furrows, thus does not penetrate deep. Such a method was sufficient in basin irrigation, because the soil took its due rest and airing in the Sharaiy period.

If these ploughs were substituted by a plough type which plough deeper and, which invert the soil, we may, in this way, compensate, to an extent, the lack of Sharaiy, by exposing more soil to the air, and simultaneously by letting the air penetrate in the deeper furrows which would result from such ploughing. This though may appear a bit theoritical, it deserve an experiment. So far as we know, some big land oweners use mechanical ploughs. All we need is to study the output of such ploughed lands and compare it with other land ploughed by the native wooden plough. In such a study one must take in consideration much different elements. For example one should not compare the mean output of a feddan in a big estate with that of very small holding. Small holdings —though wide spread in Egypt —does not represent the usual agricultural pattern, but it is more like horticulture. In a small holding the members of the family actually work every bit of land manually. We should then compare the output of big holdings using wage labour, and using on the one hand wooden ploughs and on the other hand mechanical ploughs.

If mechanical ploughs are found useful in increasing the output, there is another problem which should be faced; small holdings cannot afford such costy ploughs. But the roots of overcoming such a problem may be

found in what we have observed in a small village in Central Delta. To thresh corn the Egyptians use a special cart or wagon with sharp-edged iron wheels which is drawn either by one or two animals. This implement is used since a very long time in Egypt. Some five years ago the peasants of this village —and probably in many places in the Egypt— can hire a tractor of a rich neighbour, and let the tractor pull three to five threshing waggons, one behind the other. In this way a work of a week done by the slow animals and one cart, is done in a day or two by the quick tractor and the triple number of threshing waggons. In a similar way mechanical ploughs can be used. The spread of mechanical ploughs would end, among others, in the following results :

1. Quick ploughing would result in relieving many working hands for other periodic wage-labour, increasing thus the private income.

2. Relieving the animals from a part of their hard work, thus enabling Egypt to develop animal husbandry and dairy production.

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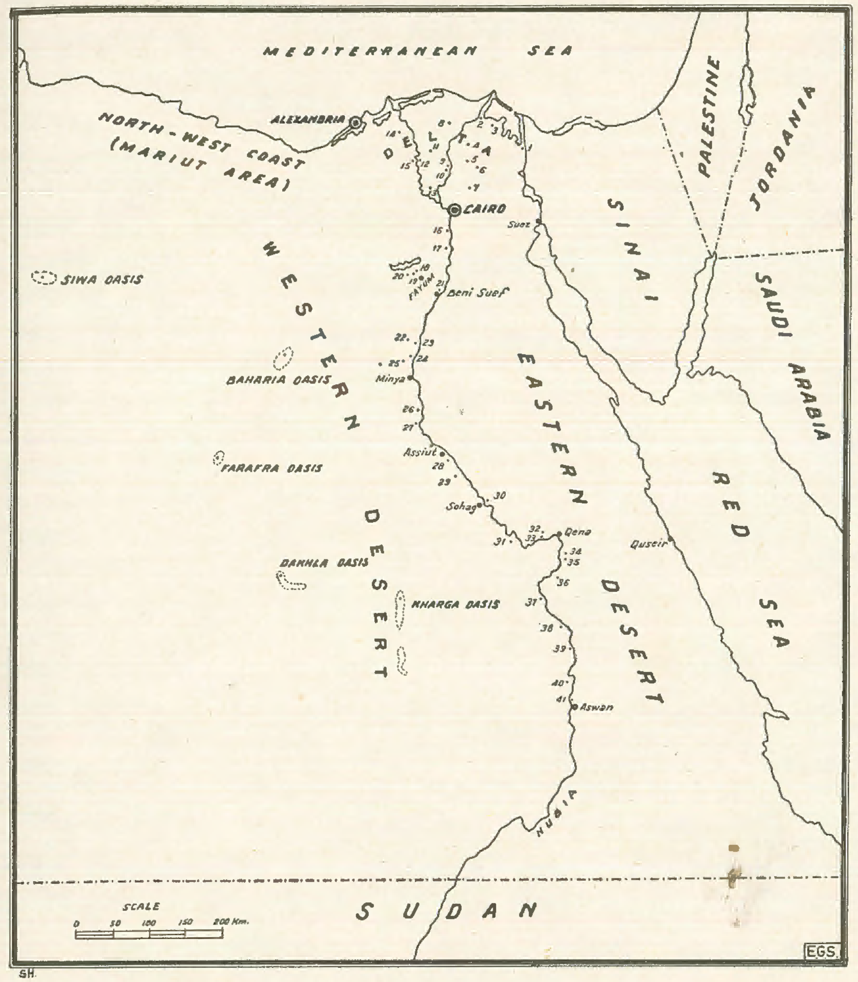


Fig. 4. Names of Localities where Studies on the plough were carried out.

1. Qantara West.
2. Genemia.
3. Busrat.
4. Nub.
5. Ibrahimia.
6. 'Ezbet Maher.
7. Bilbies.
8. Bieala.
9. Zefta.
10. Sa'ad Pacha.
11. Shony.
12. Mishla.
13. Kamshush.
14. Sanhur.
15. Netma.
16. Tammu.
17. 'Ayat.
18. Fidimin.
19. Sinero.
20. Zeid.
21. Man'aris.
22. Edab'iy.
23. Beni Mazar.
24. Golosna.
25. Shosha.
26. Mallawi.
27. Garf Serhan.
28. Nazlet 'Abdalla.
29. Aulad Mohamed.
30. El-'Ezbi.
31. Aulad 'Imran.
32. Abu Mana'a'.
33. Essaberiat.
34. Kiman.
35. Harragia.
36. El-'Ammari.
37. Nouasir.
38. Kelh.
39. Ramadi-South.
40. Benban.
41. Baharif Is.

Appellations Regionally Used to Different Parts of the Native Plough in Egypt.

Place of Observation	Base	Share	Handle	Iron bands	Handle grip	Beam
Eastern Delta :						
Qantara West (2)	Bazh̬a	Silah̲	Romh̲	—	Maqbaḍ	Ous
Genemiā (2) (+)........	»	»	Riesh	—	Yadd	Aṣabā
Ḃuṣraṭ (3) (+)	»	»	»	—	—	Aṣabā
Nub (3)................	»	»	Romh̲	—	Gabḍa	Gōs
Ibrahimia (1)				Gafiez	»	»
ʿEzbet-Maher (1)	»	»	»	»	»	»
Bilbies (2).............				Afiez	Abḍa	Ous
Bilbies (3)				—	»	»
Ibrahimia (1) (=).......					Gabḍa	Gōs
ʿEzbet-Maher (1) (=)....	»	»	»	—	»	»
Bilbies (2) (=)					Abḍa	Ous
Bilbies (3) (=)						
Bilbies (2) (±).........	»	»	»	—	»	»
Bilbies (2) (++)........	»	»	»	—	»	»
Central Delta :						
Bieala (2)..............	»	»	Riesh	—	Yadd	Aṣaba
Bieala (2) (±) I)	—	»	»	—	»	—
Zefta (2)	Bash̬a	»	Romh	—	Gabḍa	Aṣaba
Saʿad Pasha (1) (=).....	»	»	»	—	»	Ous
Shony (2)...............	»	»	Riesh	—	Ieyd	Aṣaba
Mishla (1)	»	»	Raiash	—	ʿOukṣā	»
Kamshush (3)	»	»	»	—	Rimh̲	»
Kamshush (3) (±)......	»	Lisan el ʿasfur	»	—	»	Ous(= =)
Western Delta :						
Sanhur (3)	»	Silah	Riesh	—	—	Gaṣabi
Netma (1)..............	»	»	»	—	ʿOukṣa	Aṣaba
Middle Egypt :						
Ṭammū (3) (+).........	»	»	»	—	Abḍa	Aṣaba
ʿAyaṭ (2) (+)...........	»	»	Gabaien	—	»	H̲igr
Fidimin (3) (+)	»	»	»	—	—	»
Sinero (2) (+)	»	»	»	—	Masnad	»
Zeid (2) (+)............	»	»	»	—	»	»
Manʿaris (3) (+)........	»	»	»	—	ʿUbad	»
Edabʿiy (1) (+)	Wish	»	»	—	Gabḍa	Gaṣaba
Beni Mazar (2) (+)	»	»	»	—	»	»
Golosna (3) (+)	»	Sikka	»	—	»	»
Shosha (1) (+)	»	Silah̲	»	—	»	»

Place of observation	Base	Share	Handle	Iron bands	handle grip	Beam
Upper Egypt :						
Mallawi (3) (+).........	Wish	Sikke	Gafaien	Ṭog	Gabḍa	Gaṣaba
Garf Serh̲an (2) (+).....	»	»	»	—	»	»
Nazlet ʿAbdalla (3) (+)...	»	»	Dafaien	Dibel	Yadd	»
Aulad Mohamed (3) (+) .	»	»	Gafaien	Ḍog	Gabḍa	»
El-ʿEzbi (3) (+)	»	»	»	Ṭog	Babba	»
Aulad ʿImran (3) (+) ...	»	»	»	»	Dabba	»
Abu Mannaʿ (1) (+)	»	»	»	»	Gabḍa	»
Eṣṣaberiat (1) (+).......	»	»	»	»	»	»
Kiman (3) (+)	»	»	»	Dibel	»	»
H̲arragia (2) (+)........	»	»	»	»	»	»
El-ʿAmmari (1) (+)	Wagh	»	»	»	»	»
Nauasir (3) (+).........	Wish	»	»	»	Magbaḍ	»
Kelh (3) (+)............	Wigh	»	H̬add	»	»	»
Ramedi South (1) (+)...	»	»	Gafaien	»	»	»
Benban (3) (+).........	Wagh	»	H̬add	»	»	»
Bah̲arif (3) (+)	Sikke	»	Rigil	»	Yadd	
Palastine :						
Southern area (2) (=) (±)	Arḍiya	H̲aseem	Romh̲	—	H̲amama	Kooʿ
Libya :						
Tripoli (2) (=) (±)	El-Layṭa	Sikka	Seluqiua	—	Qarraṣṣa	Raqaba

(1) Ploughs observed by the author.
(2) Ploughs described by some students of the author (faculty of Arts, Ain-Shams Univ.).
(3) Ploughs described by H. A. Winkler pp. 153-158 (see references below).
(+) Double handle plough.
(=) Curved beam plough.
(±) One animal plough (usually garden plough).
(++) Wheeled plough (usually used in sandy areas).
(±) I) Wheeled plough (usually for vegetables).
(= =) The first part of the beam, which is attached to the share is called Wasle, while the forked fore part of the beam is called Arish, and the whole is called Ous. see Winkler, H. A., p. 154.

Transcription :

ʾ همزه	h̲ ح	h̬ خ	Sh ش	ṣ ص
ḍ ض	Ṭ ط	ʿ ع	Ġ غ	q ق

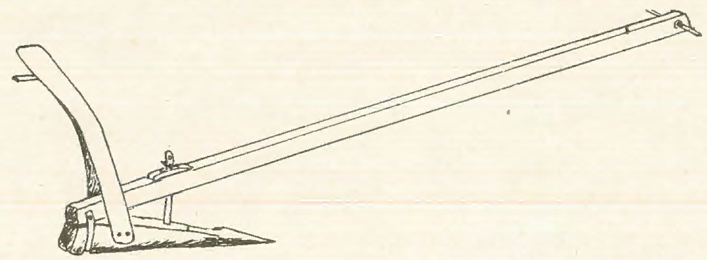
This Sign —on any vowel means elongation of the vowel.

Place of observation	Fastner; base with beam	Pin	Pin supporter	Beam Extension	Fastner; beam with beam extension	cross peg of beam or beam extension
Eastern Delta :						
Qantara West (2)	Ṭō'	Balanga	—	—	—	Bantot
Genemiā (2) (+)	»	»	—	—	—	Lantot
Buṣraṭ (3) (+)	Ṭog	»	—	—	—	Antot
Nub (3)	—	»	Shinhab	—	—	Bantot
Ibrahimia (1)	Gafiez	»	»	—	—	»
ʿEzbet-Maher (1)	»	»	»	—	—	»
Bilbies (2)	Afiez	»	—	—	—	»
Bilbies (3)	Ṭog	»	Faṭs	—	—	»
Ibrahimia (1) (=)	—	»	—	Waṣla	Shamber	»
ʿEzbet-Maher (1) (=)	—	»	—	»	»	»
Bilbies (2) (=)	—	»	—	»	»	»
Bilbies (3) (=)	—	»	—	»	—	»
Bilbies (2) (±)	—	»	—	—	—	—
Bilbies (2) (++)	—	»	—	—	—	Bantot
Central Delta :						
Bieala (2)	Ṭō'	»	—	—	—	Antot
Bieala (2) (±) I	—	—	—	—	—	—
Zefta (2)	Ṭō'	Balanga	—	—	—	Antot
Saʿad Pasha (1) (=)	—	»	—	Waṣla	Shamber	»
Shony (2)	Ṭō'	»	—	—	—	»
Mishla (1)	»	»	—	Waṣla	Shamber	»
Kamshush (3)	»	»	—	—	—	»
Kamshush (3) (±)	Balanga	»	—	—	—	—
Western Delta :						
Sanhur (3)	Ṭog	»	—	—	—	»
Netma (1)	Ṭō'	»	—	—	—	»
Middle Egypt :						
Ṭammū (3) (+)	Ṭō'	Magrum	—	Waṣla	Shuḍab	—
ʿAyaṭ (2) (+)	Bagrōm	Balanga	—	»	Shuḍab	Douar
Fidimin (3) (+)	Ṭō'	Bagrōm	—	Ṣaffiṭ	Gars	Gars
Sinero (2) (+)	Bagrōm or Iyl	»	—	Ṣaffit	»	Shaḍḍab

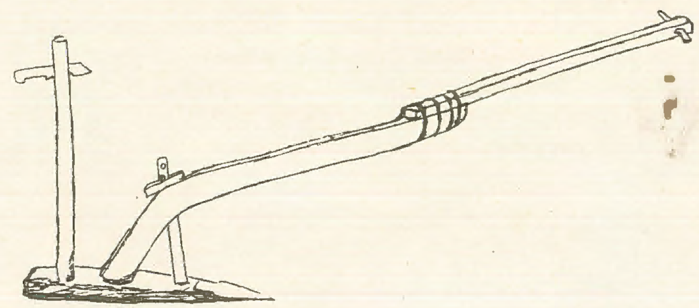
Place of observation	Fastner; base with beam	Pin	Pin supporter	Beam Extension	Fastner; beam with beam extension	Cross peg of beam or beam extension
Zeid (2) (+)	Iyl	Bagrōm	Masanid	Waṣlet-Etta'ab	Ta'ab	Shaḍḍab
Man'aris (3) (+)	»	»	Masned	Ṣaffit	Shaddab	» or wiri
Eḍabʿiy (1) (+)	Musmar	»	»	Heēm	Abu-Elgurōn	Shaḍḍab
Beni Māzar (2) (+)	Ṭog	Balanga	—	»	Elgureēn	Shuddab
Golosna (3) (+)	Gil	Mesned	without a special name	»	Gerēn	Shidab
Shosha (1) (+)	Musmar	Bagrōm	Masned	»	Abu-Elgurōn	Shaddab
Upper Egypt :						
Mallawi (3) (+)	Gil	»	»	»	»	ʿAṣfur
Garf Serḥan (2) (+)	»	»	»	»	»	
Nazlet ʿAbdalla (3) (+)	Gurrab	Badrum	»	Garāda	Barūf	Weri
Aulad Mohamed (3) (+)	»	Moftah	»	Garage	Bazḫa	Weiār
El-ʿEzbi (3) (+)	»	»	»	Garagi	Bazḫi	Barūf
Aulad ʿImran (3) (+)	»	Miftah	»	Karagi	Guṭṭa	Mindif
Abu Mannaʿ (1) (+)	»	»	»	Kuraga	Ḥabur	»
Eṣṣabariat (1) (+)	»	»	»	»	»	»
Kiman (3) (+)	»	»	»	»	»	»
Ḥarragia (2) (+)	ʿOgb	Dabbōs	»	»	»	»
El-ʿAmmari (1) (+)	»	ʿAmūd	»	»	»	»
Nauaṣir (3) (+)	Gurrab	»	Ḥabur	»	»	»
Kelh (3) (+)	»	Ḍul	Mesned	»	»	»
Ramadi South (1) (+)	»	ʿAmūd	»	»	»	»
Benban (3) (+)	»	»	»	—	—	»
Baḥarif (3) (+)	»	»	Gafir	—	—	Messala
Palestine :						
Southern area (2) (=)(±)	—	—	—	—	—	—
Libya :						
Tripoli (2) (=) (±)	—	—	—	—	—	—

Place of observation	Rope connecting beam with yoke	Yoke	Outer peg of the yoke	Inner Peg of the yoke	Middle Peg of the yoke	Rope connecting yoke with animal
Eastern Delta :						
Qantara West (2)	Gēd	Naf	Gunāfa	Soba'	Musmar	H̱unnāg
Genemiā (2) (+)	»	»	Ounāfa	»	»	Deshida
Buṣraṭ (3) (+)	'ēd	»	»	»	»	—
Nub (3)	Ged	»	Deshida or gunāfi	ʿAṣfur	'Aṣfur	—
Ibrahimia (1)	»	»	Gunāfa	»	'Asfur Wastani	Dishida
ʿEzbet-Maher (1)	»	»	»	»	»	»
Bilbies (2)	'ēd	»	Ounāfa	»	»	H̱abbl
Bilbies (3)	Ged	»	Gināfa	»	'Aṣfur	—
Ibrahimia (1) (=)	»	»	Gunāfa	»	'Aṣfur Wastani	Deshida
ʿEzbet-Maher (1) (=)	»	»	»	»	»	»
Bilbies (2) (=)	'ēd	»	Ounāfa	»	'Asfur	H̱abbl
Bilbies (3) (=)	Ged	»	Gunāfa	»	»	—
Bilbies (2) (±)	'ēd	»	Ounafa	—	—	Habbl
Bilbies (2) (++)	»	»	»	»	'Asfur	»
Central Delta :						
Bieala (2)	Ged	»	»	»	»	Deshida
Bieala (2) (±) I)	Salab	»	»	—	—	»
Zefta (2)	Ged	»	»	ʿAṣfur	'Aṣfur	»
Saʿad Pasha (1) (=)	»	»	H̱unnāg	»	'Aṣfur Wastani	»
Shony (2)	'ēd	»	Maḫna'a	»	Bakara	»
Mishla (1)	Ged	»	H̱unna'a	»	Ba'ff	Maḫna'a
Kamshush (3)	'ēd	»	Ounāfa	»	'Aṣfur	—
Kamshush (3) (±)	—	»	»	—	—	—
Western Delta :						
Sanhur (3)	'ēd	»	Gunāfi	ʿAṣfur	'Aṣfur	—
Netma (1)	»	»	H̱unna'a	»	»	Maḫna'a
Middle Egypt :						
Ṭammū (3) (+)	»	»	Ounāfa	Ounaf	Musmar	—
ʿAyaṭ (2) (+)	»	»	»	ʿAṣfur	»	Maḫna'a

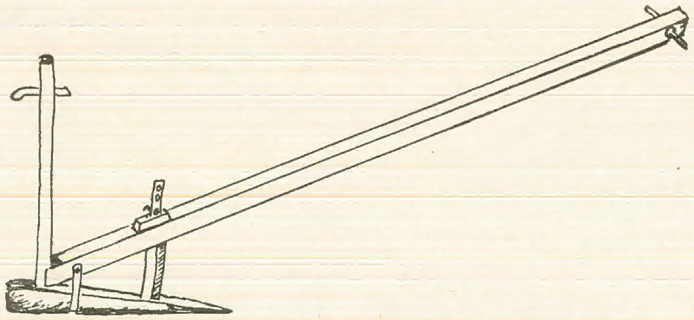
Place of observation	Rope connecting beam with yoke	Yoke	Outer Peg of the yoke	Inner Peg of the yoke	Middle Peg of the yoke	Rope connecting yoke with animal
Fidimin (3) (+)	'ēd	Ḏanaḍ	Ounāfa	Ounāf	Musmar	—
Sinero (2) (±)	»	»	»	»	el-Maqsam	Maḫna'a
Zeid (2) (+)	»	»	»	»	»	»
Man'aris (3) (+)	Wirē	»	»	»	no name	—
Eḏabʿiy (1) (+)	»	Karab	Gunāfa	Ṣuba'	Subaʿ	Maḫna'a
Beni Mazar (2) (+)	Ged	»	»	Ḥabur	Ḥabur	Gunafa
Golosna (3) (+)	»	»	»	Ṣuba'	Ṣubaʿ	—
Shosha (1) (+)	»	»	»	»	»	Gunafa
Upper Egypt :						
Mallawi (3) (+)	Wire	»	Gale	Musmar	Musmar	—
Garf Serḫan (2) (+)	»	»	»	»	»	Maḫna'a
Nazlet ʿAbdalla (3) (+)	»	»	»	—	»	Muḫnaga
Aulad Mohamed (3) (+)	»	»	Gile	Gile	»	»
El-ʿEzbi (3) (+)	»	»	»	'Aṣfur	»	»
Aulad ʿImran (3) (+)	»	»	Gille	Za'fur	Za'fur	»
Abu Mannaʿ (1) (+)	»	»	»	»	»	»
Ebaṣṣariat (1) (+)	»	»	»	Sa'fur	Ṭa'fur	»
Kiman (3) (+)	»	»	»	»	»	»
H̱arragia (2) (+)	»	»	»	Zaḫfur	Zaḫfur	»
El-ʿAmmari (1) (+)	»	»	»	Ṭa'fur	Ṭa'fur	»
Nauasir (3) (+)	»	»	»	»	»	»
Kelh (3) (+)	Ura	»	Rikkbe	Za'fur	Za'fur	»
Ramadl South (1) (+)	Hora	»	»	—	—	»
Benban (3) (+)	»	»	»	—	—	»
Baḫarif (3) (+)	»	»	Musraga	—	—	»
Palastine :						
Southern area (2) (=)(+)	Salab	Nier	Shōḫa	Shōḫa	Musmar	Habbl
Libya :						
Tripoli (2) (=) (+)	Habbl	—	—	—	—	Habbl



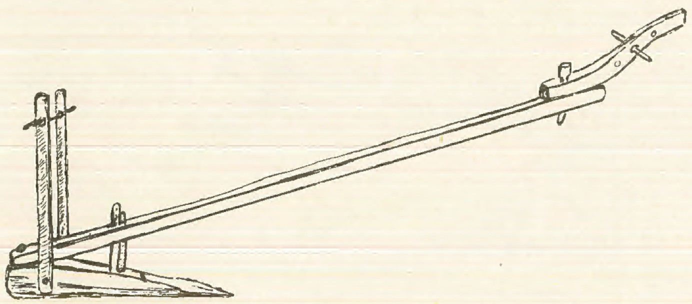
(a) — Type I. Split handle. — Straight beamed Plough.



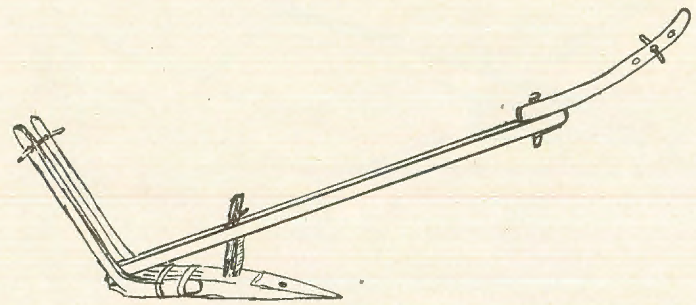
(b) — Type II. Single handle. — Curved beamed Plough.



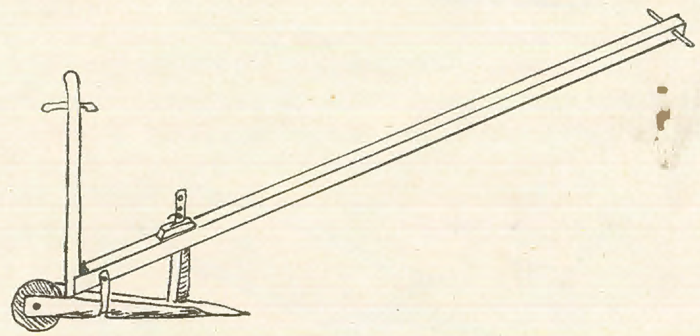
(a) — Type III. Single handle. — Straight beamed Plough.



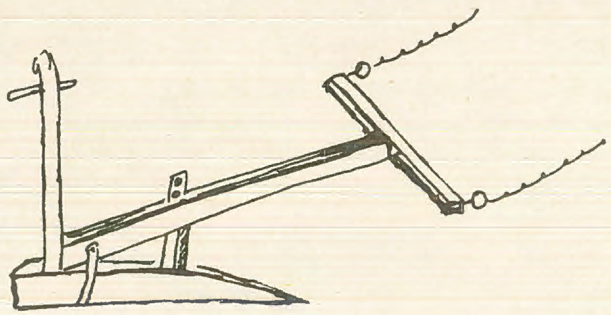
(b) — Type IV. Right-angled double handle Plough.



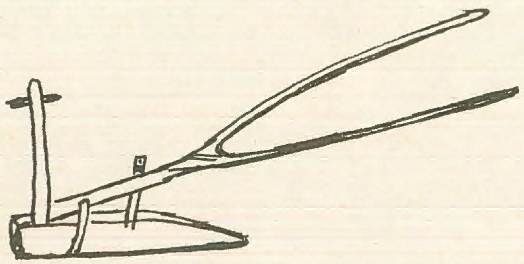
(a) — Type V. Obtuse angled double handle Plough.



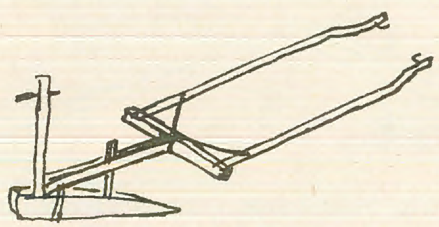
(b) — Type VII. Single handle. — Straight beamed and wheeled Plough (Bilbies).



(a) — Bilbies.



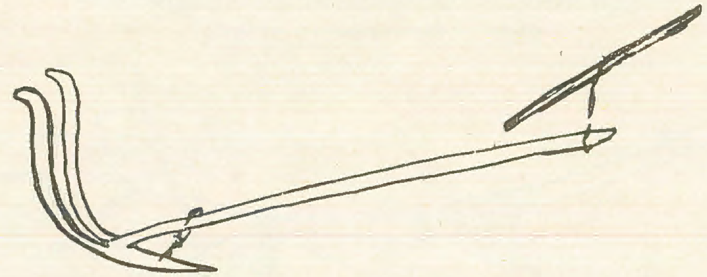
(b) — Kamshush (after Winkler).



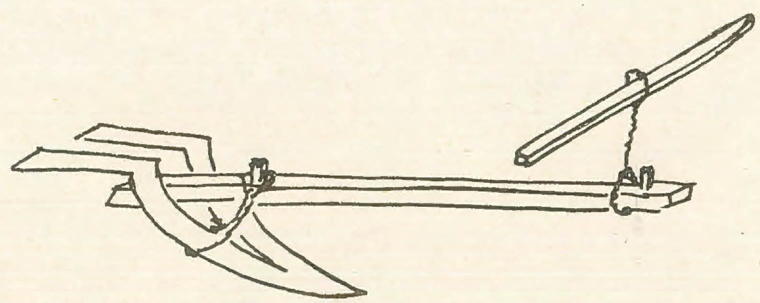
(c) — After S. M. Behiery.

Type VI. Single handle. — Straight and short beamed Plough (Garden type).

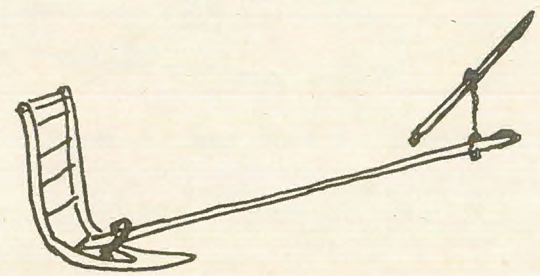
EVOLUTION OF THE EGYPTIAN PLOUGH
I. DYNASTIC PERIOD



(a) — Old Kingderm (after Erman, fig. 205).

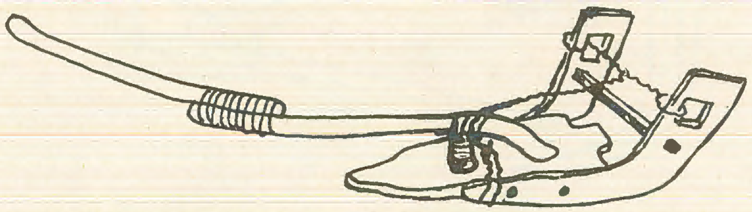


(b) — 11-12 dynasty 2100-1800 B. C. wood figure, British Museum (after Breasted, Plate 72).

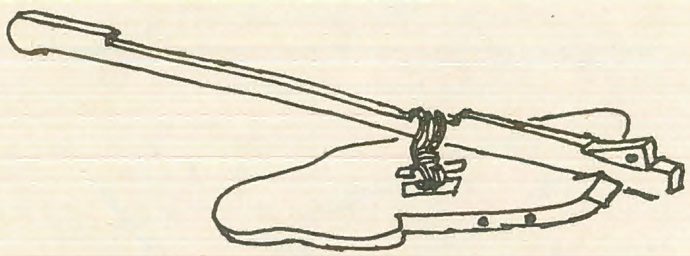


(c) — New Kingdom (18th. dynasty), (after Erman, fig. 203).

EVOLUTION OF THE EGYPTIAN PLOUGH
II. GRECO-ROMAN PERIOD

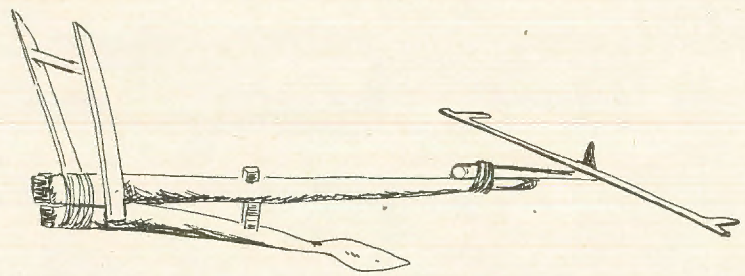


(a) — Harit Plough [Fayum], double handle. — Curved beamed Roman Period (origin Egyptian Museum, Cairo).

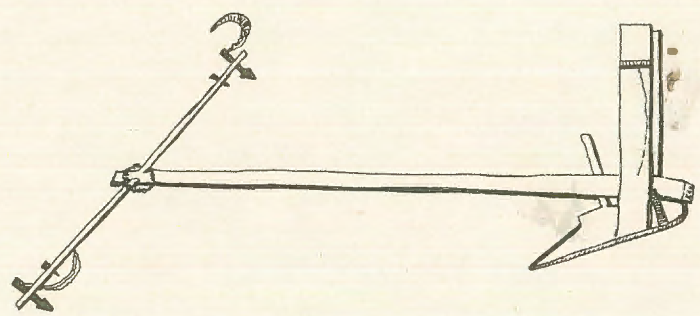


(b) — Darb Gerza Plough double handle. — Straight beamed Greco-Roman Period (origin Berlin Museum, drawn after Model in the Agriculture Museum, Cairo).

EVOLUTION OF THE EGYPTIAN PLOUGH
III. MODERN TIMES



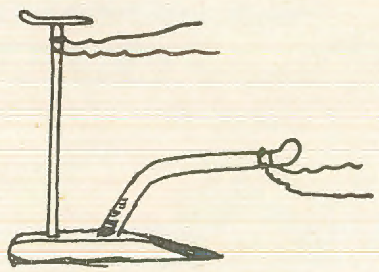
(a) — The Egyptian Plough after Norden (mid 18th. Century) Upper Egypt (See Norden, Pl. LVI, pp. 54-55).



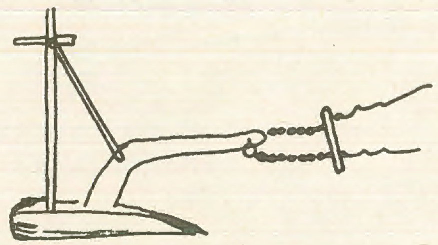
(b) — The Egyptian Plough after Description de l'Égypte [late 18th. Century] (Planche IX, Tome II, État Moderne).

CURVED BEAMED PLOUGHS (MEDITERRANEAN REGION)

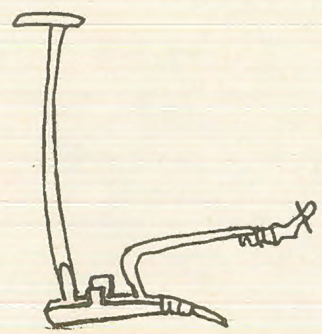
(a) — Southern Palastine.



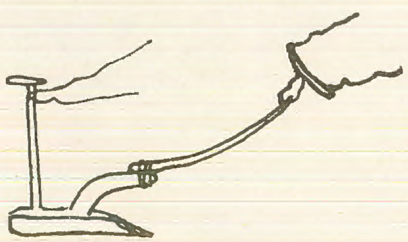
(b) — Tripoli.



(c) — Tunisia (After Baumann, p. 311).



(d) — Valley Hadramut Southern Arabia (After Helfritz, Photo 37).



AN ECOLOGICAL STUDY OF KHARGA AND DAKHLA OASES

BY

A. M. MIGAHID, M. EL SHAFEI ALI, A. A. ABD EL RAHMAN AND M. A. HAMMOUDA.

INTRODUCTION

In the winter of 1959 the authors of the present work arranged a botanical excursion to Kharga and Dakhla Oases. The botanical importance of these oases is that they represent one of the main phytogeographical regions of Egypt. They have their characteristic vegetation and ecological conditions. They are quite rainless and separated from the Nile Valley to the east and from the Mediterranean semi-desert to the north by the waterless barrier of the Libyan desert. The oases are strung up in one line of depressions surrounded by barren rainless desert on all sides. However, they are fertile and their fertility is due to the presence of artesian water in layers of sandstone at considerable depth underground. Such underground water has been raised to the surface by drilling wells to the proper depth. Cultivation and irrigation on that underground water became possible, and the oases could accordingly be inhabited.

Recently, the oases have attracted the attention of government authorities as a possible addition to the cultivated area of the country. The population of our country is increasing and new resources have to be thought of in order to raise the present standard of living. Ranking first among these resources is the utilisation of every bit of cultivable land. Since the oases represent vast areas of such land in the desert, scientific studies in the fields of hydrology, geology, ecology, pedology and agriculture have become very important in order to base reclamation and utilisation on firm grounds.

Our excursion was of ten days duration. During that period ecological and botanical reconnaissance of the two oases was made. Detailed investigations of various problems must follow such a general study.

The authors wish to thank Mr. M. N. El Shourbagui and Mr. S. El Saadawi for their valuable help.

Location.

Oases are fertile areas in the desert, which owe their existence to the combined and interrelated effects of topographical, geological and hydrological factors.

Kharga Oasis (Map Fig. 1) is confined between latitudes 24°30'N. and 26°00'N. and between longitudes 30°27'E. and 30°47'E. It has a length of approximately 140 kms north to south and a breadth of 15 to 35 kms east to west. The northern part represents the main inhabited and cultivated area. On the south and west, the oasis merges gradually into the adjoining desert plateau while on the north and east there is a rather steep escarpment.

Dakhla Oasis (Map Fig. 2) is located west of Kharga, between latitudes 25°28'N. and 25°44'N. and between longitudes 28°48'E and 29°21'E. Its length is approximately 55 kms from north-west to south-east, and its breadth varies between 10 and 20 kms. Cultivated areas are located around the villages.

Topography and Geology.

Wind erosion has reduced the general level of the oases depression from a general plateau level of 300-400 m. above sea level to less than 100 m. in Kharga and 200 m. in Dakhla.

Within the Nubian formations occur porous sandstones which carry water at a hydrostatic head of approximately 100 m. in Kharga and 120 m. in Dakhla. Under these conditions occur the artesian springs which supply the oases depression with its water.

The general geological structure of the oases area was described by Power and Pretorius (1954) as follows : The rocks involved are Eosene limestones, Cretaceous limestones, Nubian sandstones and Archean

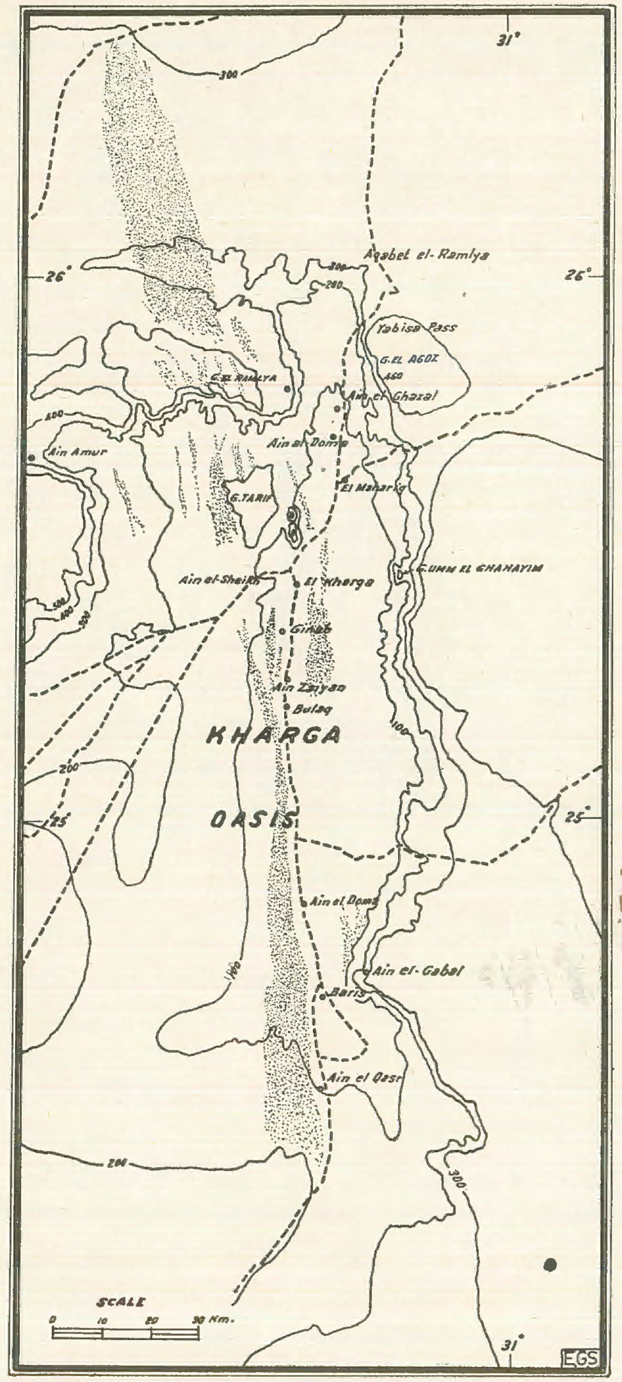


Fig. 1. Kharga Oasis.

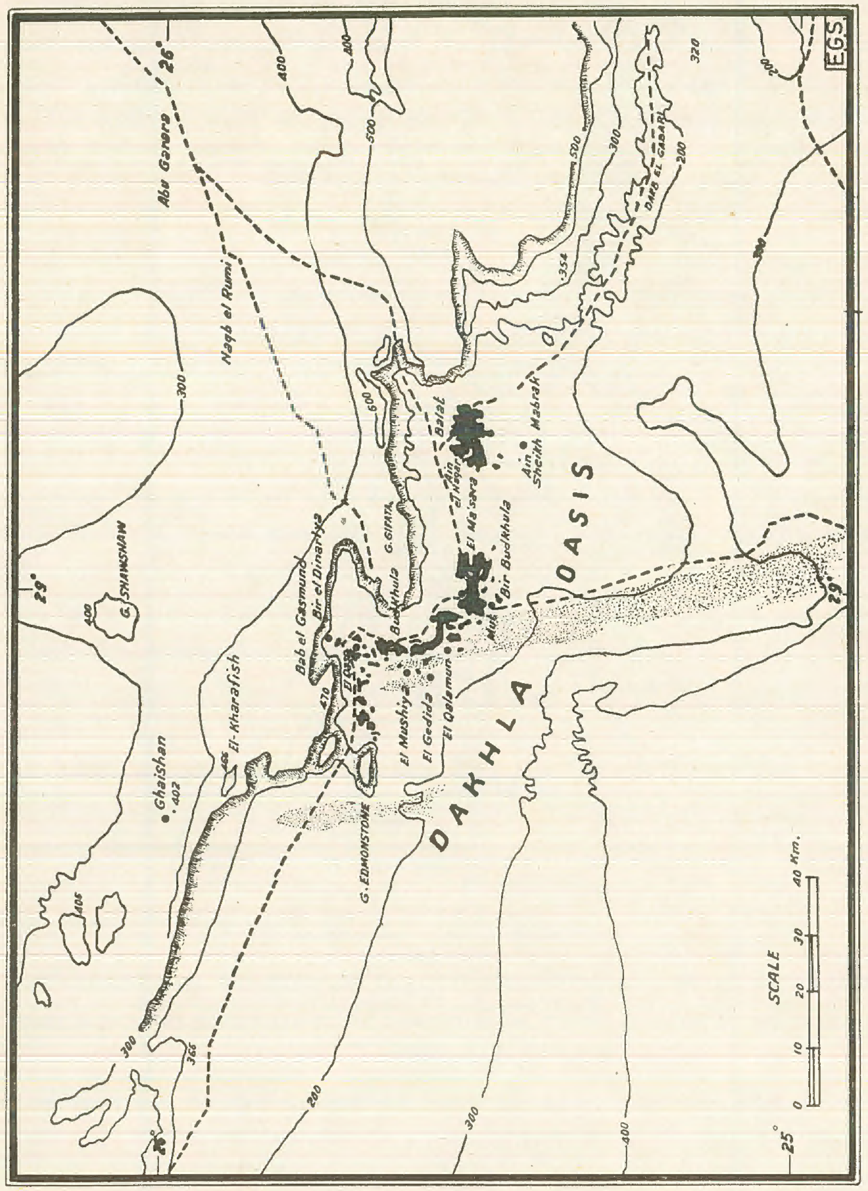


Fig. 2. Dakhla Oasis.

granites. According to Oliver (1930-1931) the limestone forming the plateau is of Eocene age, and beneath this is found the chalk of the Upper Cretaceous, followed by various shales and sandstones, till the artesian

water-bearing sandstone is reached at a depth of 400-500 f. below the oases floor. Conspicuous surface features of the floor are the sand dunes and clays.

Hydrology.

Some hydrogeologists believe that the artesian waters of the oases are derived from rain that falls in the Sudan and flows underground in the permeable beds of the Nubian sandstone. Others believe thay they are merely Nile waters which have penetrated into the adjoining deserts. Ball (1927) is against the view that the artesian water of oases is derived from the Nile, and believes that under the large area of the Libyan Desert there is a continuous sheet of subterranean water from which all the desert supplies are derived. This sheet supplies the wells of the oases.

There is more than one water-bearing stratum. In Northern Kharga there are two distinct water-bearing sandstone strata separated by a 75-metre band of impermeable grey shale. The upper bed is exposed at the surface and forms the true artesian water sandstone from which the flowing wells of Kharga derive their supply.

In Dakhla the water supply is derived from a bed of white sandstone which corresponds to the surface-water sandstone of Kharga.

Climate.

The southern oases of the Western Desert, namely, Kharga and Dakhla, are located in a dry rainless part of the Great Sahara. The rainfall is practically nil while the mean annual relative humidity is of the order of 40-45 %. The relative humidity is lower in summer than in winter, and is usually lowest during the early afternoon hours. Thus in Kharga it ranges between 60 % in December and 38 % from May to August. At 2 p.m. the annual mean is 32 %, with a range of 41 % in January to 26 % in August. For Dakhla the annual range is between 53 % in December and 30 % in June and July, while the range at 2 p.m. is between 38 % in December and January and 32 % in June and July. The mean annual evaporation is the highest for all the country in Kharga oasis, being 18.4 mm/day and ranging from 25.1 mm in June to 9.5 mm

in January. The air temperature is moderate in winter but rises very high in summer. The mean daily maximum in July is about 40°C and there are record maxima of slightly less than 50°C in both oases.

In Table 1 is given a summary of the meteorological data for Kharga and Dakhla oases.

According to Walter's map of the clima-diagrams of Africa the climate of the oases is of the extremely arid type. The pulviothermic quotient (Emberger, 1951 and 1955) is nearly zero in both oases, indicating extreme aridity.

HABITATS AND VEGETATION

The following types of habitat are met with in the two oases :

1. Sand Plains
2. Sand Dunes
3. Waste Land
4. Cultivated Land
5. Salt Marshes
6. Aquatic Habitat

A short description of each of these habitats and the type of vegetation it supports will be given here.

1. *Sand Plains.*

Sand plains in the oases are flat expanses of wind-drifted siliceous sand. In Kharga they are distributed in different places, especially between Kharga village and Ganah and between Ganah and Bulaq. In Dakhla there is a broad sandy plain in Wadi El Akola (= *Alhagi* valley) at about kilo 150 Kharga-Dakhla Road. Sand plains also surround most of the villages of Dakhla, especially the northern ones : El Kasr and Gedida.

The following is a description of one of these plains, which may be considered as a typical example of the habitat type. It is found in Kharga, north of Ganah, being very extensive, with flat even relief. There are,

TABLE 1

The Climate of Kharga and Dakhla Oases [1]

PERIOD OF OBSERVATION	Kharga	Dakhla
	1926-1945	1905-1915 & 1931-1945
TEMPERATURE.		
Means for the whole year :		
Mean annual temperature	23.6°C	22.8°C
Mean daily maximum	32.3°C	31.9°C
Mean daily minimum	15.9°C	15.0°C
Mean for January (Coldest month) :		
Daily mean	13.1°C	12.3°C
Daily max.	22.1°C	21.5°C
Daily min.	6.0°C	4.8°C
Means for July (hottest month) :		
Daily mean	31.4°C	30.8°C
Daily max.	39.5°C	39.2°C
Daily min.	23.4°C	23.1°C
Record maximum	48.0°C (16-5-27)	49.4°C (18-6-33)
Record minimum	2.1°C (9-2-32)	4.0°C (24-1-41)
RELATIVE HUMIDITY.		
Means for the whole year :		
Mean annual	46 %	40 %
Range	60 % in Dec. to 38 % from May to Aug.	53 % in Dec. to 30 % in July & Aug.
Mean at 2 p. m.	32 %	26 %
Range	41 % in Jan. to 26 % in Aug.	3 % in Dec. to 22 % in June and Jul.
RAINFALL		
Total annual	0.0 mm	1.0 mm
No. of days with more than 1 mm. rain	0.2 days	0.4 mm
No. of days with more than 0.1 mm. rain	0.7 days	0.8 mm
EVAPORATION		
Mean annual	18.4 mm/day	13.5 mm/day
Mean for January	9.5 »	6.4 »
Mean for June	25.1 »	20.0 »
WIND FORCE		
Mean for the year (Scale 0-12)	1.2	1.5

[1] Data taken from Climatological Normals of Egypt, Meteor. Dept., Cairo 1950.

however, minor undulations of the surface, caused by wind action. The sand is coarse, pale yellow and wind-transported. It forms a surface sheet of 30-50 cm thickness, overlying a substratum of clay. In Dakhla, near Kasr, the substratum is hard rock.

Wandering within the sand plains there are mobile dunes of 20-30 m height. Wind action is very severe on these dunes as it is on the sand plains. The sand that covers the surface of the latter is derived mainly from the dunes. The processes of sand blowing and sand deposition usually go hand in hand. Any place which may be subjected to wind erosion at one time may receive deposited sand at another time. Such continual wind action causes unstability of the soil and of its thickness, which in turn has its effect on the plant cover. Thus sand plains are sterile in exposed parts, but may support a sparse vegetation in sheltered parts, e. g. in the shelter of dunes.

To the north of the sand-plain here described there is a series of young mobile dunes, uncovered with vegetation. These northern dunes intersect another series of dunes on the eastern side of the plain. The direction of the prevailing wind is NW-SE. The eastern dunes are old and stabilised by vegetation. The sand in the low ground at the meeting point of the two dune series is more sheltered and more stable than that in the open plain some distance away. Consequently in the sheltered corner there developed a community of *Cressa cretica* in the forward concavity of one of the Barchans (Pl. I, A) and another one of *Alhagi maurorum,* associated with *Aristida scoparia* in other parts of the protected corner. In open parts of the plain there were no living plants. Only dried stumps of doum trees, *Tamarix* and other plants were found, representing the remnants of a previous plant cover. The latter has evidently developed on the clay substratum before it was covered by the wind-drifted sand. The sand at one time had dunes under which the overwhelmed plants were buried and dried. After the dunes have moved away from the area the dried stumps became exposed again.

The *Cressa* community in the sheltered corner was open and pure. The overground parts of the plant reached a height of 10-30 cm. The plant has a creeping rhizome from which aerial branches come out at intervals. The *Alhagi-Aristida* community had a total cover of 5-7 %.

Aristida is a sand binder which accumulates sand to a height of half meter or so.

In the drier, elevated, sand plains of Kharga oasis grow such xerophytes as *Caletropis procera* and *Hyoscyamus muticus,* in addition to *Alhagi, maurorum* which is the dominant species in this habitat. In Dakhla other elements may be found. Thus in the sand plain near Kalamoun there is a *Tamarix* community having the following floristic composition :

Tamarix arborea	d
Caletropis procera	a
Aerva tomentosa	c
Stachys aegyptiaca	c
Suaeda fruticosa	r

Tamarix reaches a considerable size and accumulates sand to build little dunes. In some places *Caletropis* is buried completely under the drifted sand.

The strong effect of wind and sand in this type of habitat is manifested by the abrasion of fallen doum fruits, the pericarp of which has become perforated and the kernel exposed.

Soil samples from a sand-plain were collected and analysed. The results are given in Table 2.

TABLE 2

Analysis of Soil from a Sand Plain near Ganah
at 25-50 cm. Depth

		Mechanical analysis	
Saturation capacity %	= 23.2		
Carbonate content %	= 3.73	Coarse sand %	= 54.28
Total soluble salts %	= 0.33	Fine sand %	= 38.44
Conductivity (millimhos)	= 0.79	Silt %	= 2.00
Chlorides (m. eq.)	= 2.24	Clay %	= 3.00
Organic matter %	= 0.03		
pH	= 7.1		

The soil is mostly sand, with a low saturation capacity. The carbonate content, salinity and organic matter content are all relatively low. The soil reaction is neutral.

2. *Sand Dunes.*

Sand dunes at different stages of development are found abundantly in the oases. The younger dunes are mobile and uncovered by vegetation. They are of the "Barchan" type, with a high, steep forward end on the leeward side. On the same side there is a big crescentic concavity (Pl. I, A). The barchan, as described by Oliver (1930-1931) is a heap of sand driven by the wind in a definite direction. A medium sized barchan has a height of about 15 m. and a length of about 200 m. Behind the steep leeward end the barchan is extended into a tapering tail. The dune migrates slowly in the direction of the prevailing wind. "The projecting slopes", states Oliver, "travel faster than the main body and move in advance, and these cusps are kept fed with sand which slides along the perimeter on either flank of the dune". The rate of travel of Barchans, according to Beadnell (1909), ranges from 10 to 20 metres per annum.

The barchans are either isolated or arranged in chains with the concavities facing nearly south. A chain may be made of 20 or more dunes. The dunes may coalesce and their individuality becomes obscured. The supply of sand to the dunes and sand plains of the oases is replenished from the plateau of the Libyan desert.

Sand dunes represent elevations cropping out from the sand plain, and so are always associated with the latter. Thus in Kharga they are found near Ganah and Bulaq while in Dakhla they are found near the northern villages of Kasr, Kalamoun, Gedida and Bedkhoulo, where sand sheets cover the surface of the ground.

The travelling barchans are usually uncovered by vegetation since there is no stable soil on which the plants can settle. On the older, stabilished, dunes *Tamarix* spp., sometimes also *Alhagi maurorum,* grow abundantly and cover the summits as well as the slopes. Vegetated dunes usually have their higher, steep, end facing windward, while towards the leeward end develops a tapering tail of more recently deposited sand which is quite barren (Pl. I, B). As mentioned in a previous

paper by the present authors (1959), the growing plants act as a stabilizing agent which breaks the velocity of the sand-bearing wind, thus leading to deposition of the burden of sand on their shoots. *Tamarix* and *Alhagi* have the ability of rapid growing and emerging through the deposited sand. By their rapid upward growth they raise the dune bit by bit. Their underground parts are profusely branched within the mass of accumulated sand, and in this way they help to fix and stabilise the dune. However, wind continually removes sand from the summit and slopes of stabilised dunes, exposing the dried buried parts of the plant shoots (Pl. I, B).

A soil sample was collected from the top of a stabilised dune and analysed. The results are given in Table 3.

TABLE 3

Analysis of Soil from the Top of Stabilized Sand Dune at Ganah

		Mechanical analysis	
Saturation capacity %	= 15.88	Coarse sand %	= 39.8
Carbonate content %	= 3.9	Fine sand %	= 46.8
Total soluble salts %	= 0.2	Silt %	= 3.0
Conductivity (millimhos)	= 0.64	Clay %	= 3.0
Chlorides (m. eq.)	= 2.01		
Sulphates (m. eq.)	= 10.73		
Organic matter %	= 0.024		
*p*H	= 7.1		

As seen from the table the soil analysis is similar to that of the sand plains. The mechanical analysis shows that the soil texture is mainly sand with a little fraction of silt and clay. The saturation capacity is low, the soil being sandy. The carbonate content is fair, salinity and organic matter are very low. The soil reaction is nearly neutral.

In Dakhla oases, the village of El Kalamoun is surrounded by dunes which are densely vegetated with *Tamarix arborea* and few other species.

Bedkhoulo village is found on an exposed elevation, and is, therefore, permanently threatened by wandering dunes which encroach upon settlements, farms and wells. The danger of dunes and drifted sand increases progressively as one proceeds north towards Kasr. The dunes near Kasr are formed on a substratum of rock, as contrasted with those of Kharga which are formed on clay. In Pl. II, A, are seen the dunes encroaching upon doum and *Balanites* trees at Baris (Kharga).

Moving sand is a big nuisance in the oases, not only because it overwhelms dwellings, cultivations and wells but also because it lodges wherever the conditions are stabilised, e. g. by vegetation, thus raising the level. Irrigation channels are seriously affected by this. The plants clothing the banks collect sand and the channels are gradually raised. Eventually a height is reached at which the channels can function no longer and have to be replaced by a fresh system. Another effect is that wind-born sand is an important agent of erosion.

The inhabitants of the oases defend themselves against sand by growing palms and other high trees around the villages and wells, and particularly on the windward side. These act as windbreaks which relieve the wind of its burden of sand. At Ganah, 15 km. south of Kharga village, there is a big governmental farm which is surrounded on all except the southern side by successive belts of *Saccharum officinarum, Eucalyptus, Prosopis* and *Acacia,* the first-named species being the most windward.

Oliver (1931-1932) has discussed in some detail the question of sand control in the oases and has given a number of suggestions to be followed in the defence against sand attacks.

The natural vegetation of the two sandy habitats : sand plains and sand dunes, is made of xerophytic elements which derive their water supply from soil wetted appreciably by artesian water that is raised to the surfaces and allowed to flow continually overground. Although these two habitats are found in areas no longer irrigated, and in which the level of the soil surface is higher than that of cultivated land, especially in the case of stabilised dunes, yet the two commonest plants, *Tamarix* and *Alhagi maurorum,* are specially adapted to the conditions of these habitats. Both plants can develop deep and extensive roots several

metres in length. It would be a very interesting investigation to study the relation of root depth and root development to soil water content in these habitats.

3. *Waste Land.*

Vast areas of neglected land are found outside the cultivated areas. These are no longer irrigated although in the past they probably were under irrigation. They have been neglected either because of decrease in the supply of irrigation water through overwhelming of wells by drifted sand or through rise of the well head by constant accretion to the extent that artesian pressure could no longer raise the water to the surface. Or the land may have become deteriorated through salinity on account of continual irrigation and flooding with the weekly saline artesian water. Such flooding, in the absence of drainage and under the prevailing conditions of intense evaporation, causes progressive increase of soil salinity. The waste land is often intermediate in level and salinity between the salt marshes and the sand plains or the desert plateau. It supports a wild vegetation of weeds, which is sometimes fairly dense. The ground level is not very high above the level of seeping well water in the soil, and so are constantly supplied with underground water. This type of land can be utilised in agriculture if a sufficient supply of irrigation water is secured and a drainage system is established for washing away the salts.

Several areas of waste land are met with in both Kharga and Dakhla oases. The following distribution was noticed in the two oases :

A. *South of Kharga village.*

There are successive rocky ridges of medium height extending from west to east south of Kharga village, and traversed by the main road to Baris. These ridges are separated by extensive depressions of uneven relief. Some parts of these depressions are flat cultivated plains. The waste lands are found at the boundaries of cultivated areas. Deeper parts of the depressions are highly saline and inundated. They are transformed into salt marshes. In still other parts the ground surface is not

covered with free water but is just wetted and covered with a crust of salt. In these depressions 4 stands, representing the waste land habitat, were examined. These are the following :

Stand 1 : This stand occupies a neglected field that was formerly under cultivation and irrigation. The relief is even and there is a thin crust of alluvium at the surface. The soil is sandy and the area is located in the depression south of the first rocky ridge which separates it from the village of Kharga. The floristic composition of the stand is as follows :

Zygophyllum coccineum	d
Astragalus trigonus v. leucacanthus	cod
Fagonia arabica	r
Asphodelus tenuifolius	r
Moltkea callosa	r
Phlomis phloccosa	r
Pulicaria crispa	r
Hyoscyamus muticus	r

The total plant cover is 50 %. *Zygophyllum* grows vigorously in this area and reaches a height of 50 cm. and a diameter of more than one metre (Pl. II, B). At the time of our visit there were cultivations of clover and barley within a short distance from the area studied. To the south-east there were mobile sand dunes (Barchans).

The ground level is fairly high and untopped by the underground water spilled by the wells. However, the water table was so close to the surface that there was available soil water within reach the roots of the above xerophytes. The habitat is nearly a desert.

A soil sample was collected from a depth of 25-50 cm. and analysed. The results are given in Table 4.

As seen from the table, the soil is sandy, with a higher fraction of fine sand. The saturation capacity is rather low, same as the carbonate content and the salinity. The organic matter content is also low and the soil reaction is nearly neutral.

TABLE 4

Analysis of Soil from Waste Land (Stand I)

				Mechanical analysis	
Saturation capacity %		=	22.5		
Moisture content %	surface	=	0.41	Coarse sand %	= 33.2
	25 cm. depth	=	0.70	Fine sand %	= 56.1
	50 cm. depth	=	0.95	Silt %	= 6.0
Carbonate content %		=	2.21	Clay %	= 4.0
Total soluble salts %		=	0.43		
Conductivity (millimhos)		=	0.74		
Chlorides (m. eq.) %		=	0.56		
Sulphates (m. eq.)		=	6.72		
Organic matter %		=	0.12		
*p*H		=	7.4		

Stand 2 : This stand is found at a distance of ½ km. south of Stand 1 and ½ km. north of Sheikh Abboud. It is traversed by the main road. On the western side of the road the soil water content is relatively high and there is a thin crust of salt in some parts. The conditions are more marshy and more saline than those of Stand 1. The western part of the stand is composed of the following species :

Alhagi maurorum	d
Tamarix arborea	cod
Sporobolus spicatus	c
Cyperus laevigatus	c
Zygophyllum simplex	r

The total plant cover is 60 %. Date palm is also found in this locality which lies in the shelter of a hill. The soil is sandy. All the above plants accumulate sand round their shoots and so help to build up small dunes.

A soil sample was collected from this stand and analysed. The results are given in Table 5.

TABLE 5

Analysis of Soil from Waste Land (Stand 2)

	0-25 cm.	25-50 cm.	Mechanical Analysis	0-25 cm.	25-50 cm.
Saturation capacity %	= 21.9	22.7			
Carbonate content %	= 0.38	0.87	Coarse sand %	= 15.4	6.6
Total soluble salts %	= 1.03	0.74	Fine sand %	= 75.0	84.5
Conductivity (millimhos)	= 1.9	1.5	Silt %	= 2.0	2.0
Chlorides (m. eq.)	= 4.25	1.45	Clay %	= 6.0	7.0
Sulphates (m. eq.)	= 15.02	15.02			
Organic matter %	= .024	.021			
*p*H	= 7.25	7.0			

As seen from the above table, the soil texture in this stand is sand with high light sand fraction. The saturation capacity is low, the total soluble salts is higher than in Stand 1 with high chlorides and sulphate content. The organic matter is low and the soil reaction is neutral.

On the eastern side of the road opposite the above spot *Zygophyllum coccineum* and *Tamarix arborea* dominate. Associated with these are the following species :

Cyperus laevigatus	a
Aeluropus littoralis	c
Alhagi maurorum	c
Polypogon monspeliensis	c
Hyoscyamus muticus	r
Haplophyllum tuberculatum	r

The total plant cover was smaller on the eastern than on the western side. The eastern part of the stand is shown in Pl. III, A.

Stand 3 : This is a *Tamarix-Alhagi* community found at about 200 m. south of Sheikh Abboud, behind one of the ridges. West of the road are found the following species :

Alhagi maurorum	d
Tamarix arborea	cod
Sporobolus spicatus	c

All these species accumulate wind-drifted sand, and so build up little hillocks. *Sporobolus* plants cover areas of 2-3 m. diameter per plant. The total cover is about 50 %. The soil is sandy and relatively dry.

Stand 4 : This stand lies east of the road opposite Stand 3. The ground is a little higher and the soil is drier than on the west. Plant littler accumulates abundantly. The stand is dominated by *Alhagi* on the higher parts and by *Sporobolus spicatus* on the lower ones (Pl. III, B). The total plant cover is relatively very high, being 70 % or more. *Sporobolus* individuals cover little isolated mounds of 1.5 m. height and about 3 m. diameter. The soil is sandy and the stand covers a very big area.

B. *In Baris and between Kharga and Baris.*

Along the main road between Kharga and Baris there are some wells round which natural vegetation grows. In addition to palm and doum trees which are constant elements, other growth forms are also found. The area surrounding each well receives a fairly abundant water supply on which wild plants grow and limited cultivations are supported. The most important of these wells are :

1. *Ein El Hanash :* A Roman well in a depression supporting palm groves in addition to limited cultivations.

2. *Ain El Doum :* At kilo 71 from Kharga, with a relatively small discharge and densely surrounded by doum trees. Dunes, covered with Tamarisk, are scattered on either side of the main road to a considerable distance south of the Ain. Some of these dunes form continuous chains. Other species growing wild near the well are *Saccharum officinarum,*

Aristida scoparia and *Caletropis procera*. Date palm is also found. The soil is sandy.

3. *Ain Tafnees :* This is found in the village of Baris near Baris Well No 2. Round the well these is an extensive area, which is partly plain low land and partly a slope. The well yields not more than 2 kirats (200 m^3 per day). Among the trees growing in Tafnees area are *Acacia*, doum and *Balanites aegyptiaca*. On the higher ground, *Caletropis procera* is locally abundant, being associated with *Chrozophora plicata*. There are remains of dry millet stems projecting from the ground and scattered in the flat area (Pl. IV, A), indicating that it was formerly under cultivation. Some patches, especially at the foot of the slope, were dominated by *Alhagi maurorum*, which had a percentage cover of 30 %. *Alhagi* dominates on sandy areas. *Cynodon dactylon* is also found. In the old millet field grows *Balanites, Caletropis* and doum palm. A sample of soil supporting *Alhagi* was taken from a depth of 20 cm. The results of soil analysis are given in Table 6.

TABLE 6

Analysis of Soil from Waste Lands near Ain Tafnees

		Mechanical analysis	
Saturation capacity %	= 52.16	Coarse sand %	= 5.52
Carbonate content %	= 4.94	Fine sand %	= 35.84
Total soluble salts %	= 0.40	Silt %	= 14.0
Conductivity (millimhos)	= 1.00	Clay %	= 36.0
Chlorides (m. eq.)	= 1.90		
Sulphates (m. eq.)	= 8.58		
Organic matter %	= 0.57		
*p*H	= 8.4		

The data presented in the above table show that the soil is sandy clay. The saturation capacity is rather high. The carbonate content is fair, while salinity and conductivity are mild. The organic matter is here higher than in the preceding two soils and the soil reaction is alkaline.

4. *Cultivated Land.*

Cultivation depends entirely on water from deep artesian wells, of which there are several hundreds in the oases. Recently the governmental departments concerned in desert land reclamation have drilled a number of extra wells that are more efficient and have a bigger discharge than the old wells. Water is discharged under pressure and led by irrigation channels to areas under cultivation. Some of the wells date back to the Roman time, while others belong to the Faraonic period. The water comes up warm and most of the wells are ever-flowing. A means of economic expenditure of the artesian water must, however, be thought of since water is most valuable in the desert. A stop-cock may be attached to the nozzle, by which the wells can be opened and closed at will. Not only does the continual flow of water imply wastage of the valuable water but it also increases the salinity of the soil and leads to the formation of salt marshes. Areas subjected to repeated flooding and drying gradually become unsuitable for cultivation. The high aridity of the atmosphere enhances evaporation and the deposition of a crust of salt at the surface of the ground.

Date palm is the main crop in the oases. It is grown not only for its fruits but also for its fibres and dried leaves which are used in the manufacture of baskets and other articles. Doum nuts and *Citrullus* fruits are exported, together with *Acacia* fruits which are used for tanning. *Acacia* also yields a valuable timber, durable for casting the wells. *Salix safsaf* is frequent near the wells.

Scattered about in the palm groves are numerous private gardens. In these are grown vines, orange, lemon, fig, guava and apricot, in addition to vegetables such as tomatoes and sweet potatoes. The fruit products are of good quality, yet fruit growing in the oases is as yet unsatisfactory. In the opinion of the present authors there are great potentialities for extension of fruit production and future utilisation of the oases must be directed towards that end. Fruit trees have a relatively low water requirement. Once the tree has struck deep roots it requires little or in some cases no irrigation. Further, in the irrigation of fruit

trees water does not need to be spread on the surface but can be applied to a small area round each tree. In that way water is economised and deterioration of the soil through increasing salinity is avoided. There are unlimited potentialities in the oases for fruit farming, far in excess of the present production.

The cereals grown in the oases include wheat, barley, sorghum, (millet) and rice. The last-named plant can grow in salty places. Owing to its high water requirement it can be used for reclamation of saline land, provided drainage is possible. By soaking the soil in water, salts are dissolved and washed away into the drains. Sorghum is specially cultivated in Baris.

During the last few years the government has taken keen interest in reclamation and utilisation of the oases. With the drilling of new wells and increase of the water supply the cultivated area is gradually increased and new crops and vegetables have been introduced.

The present situation, in the two oases, as far as cultivated and cultivable land is concerned, is as follows :

Cultivated Land in Kharga Oasis.

At Ganah there is a governmental farm, about 20 acres in area, bounded by protection belts of plants. In that farm are grown fruit trees, crops and vegetables. The farm receives its water supply from one of the old wells.

Near Kharga village, the Desert Reclamation Service is successfully growing cereals (wheat and barley)—Pl. IV, B—on two modern wells with a high discharge. Clover and various vegetables are also grown. In Pl. V, A is shown one of the new wells drilled by the Reclamation Service at Kharga.

In the old village of Bulaq there are 10 acres of date and doum. The total area cultivated by the natives is about 200 acres, irrigated by several wells of a small discharge. The government has lately drilled a new well discharging 4000 m^3./day and sufficient to irrigate 200 more acres. In cultivated and cultivable areas near Bulaq the following weeds are met with : *Frankenia pulverulenta, Zygophyllum coccineum,*

Spergularia diandra, Aeluropus lagopoides, Bassia muricata, Asphodelus tenuifolius, Lolium perenne v. *tenue, Tamarix* spp., *Cyperus laevigatus, Mesembryanthemum nodiflorum, Polygonum equisetiforme* and *Sorghum virgatum.*

Analysis of soil from a poor wheat field at Bulaq (Table 7) has revealed that there is a very high percentage of clay at a depth of 40-50 cms.

TABLE 7

Analysis of Soil from Cultivated land in Bulaq on new Bulaq well
(Wheat growth is poor)

40-50 cm.		Mechanical analysis	
Saturation capacity %	= 48.03	Coarse sand %	= 18.0
Carbonate content %	= 3.25	Fine sand %	= 18.4
Total soluble salts %	= 1.68	Silt %	= 4.0
Conductivity (millimhos)	= 4.08	Clay %	= 56.0
Chlorides (m. eq.)	= 13.88		
Sulphates (m. eq.)	= 17.17		
Organic matter %	= 0.12		
*p*H	= 7.3		

The presence of such a clayey layer near the surface impedes aeration and offers resistance to water movement and root penetration. It is, therefore, unfavourable to plant growth. The soil has a high saturation capacity. Its content of soluble salts, though not too high, is much higher than that of cultivated land in the Nile Valley. The soil reaction is nearly neutral.

In winter, clover and wheat are irrigated at short intervals of 3 days. The water requirements of these crops are higher under the drought conditions of the oases, than in the Nile Valley. In view of the limited water resources in the oases, the authors propose to investigate the water requirements of various crops, fruits and vegetables and to give preference for growing in that region to plants with the least possible water requirements. It is also proposed to study soil profiles in various

cultivable areas, and to pay special attention to the physical properties of the soil, particularly the mechanical composition and the penetrability.

As it has already been mentioned with regard to the waste land habitat there are several wells scattered between Bulaq and Baris round which limited cultivations are supported. The plants grown include the staple crops, fruits and vegetables. Besides, there are palm and doum groves. The cultivable area round each well is much in excess of that actually cultivated. Worth of mention among these wells are Ain El Gaga at kilo 77 from Kharga yielding 3 kirats of water, Ain Dakhakheen yielding 5 kt. and Ain El Khas yielding 7-8 kt. The first two of these wells are found at a high level, with barley and wheat grown in the surrounding low land. The third well dates back to the Roman time, and is found in a depression with some cultivations round it.

Another well between Bulaq and Baris is Ain El Makhida, surrounded by extensive cultivable land. In one place near the ain is found a community of the following xerophytes : *Caletropis procera, Zygophyllum coccineum* and *Aeluropus lagopoides.* In another place the following community was supported.

Hyoscyamus muticus	d
Frankenia pulverulenta	cod
Tamarix arborea	a
Aeluropus lagopoides	a
Colocynthis vulgaris	r
Zygophyllum coccineum	r

The total plant cover was nearly 30 %.

Soil samples from that stand, taken at Depths of 0-20 and 20-40 cm, showed the analysis presented in Table 8. Although there is a high proportion of sand at the surface, the proportion of fine-grained particles increases with depth until between 20 and 40 cm. depth the proportion of clay becomes 34 %. Associated with this there is increase of salinity and water saturation capacity with depth. The tendency towards formation of a clay pan in the subsurface soil would seem to be a general phenomenon.

TABLE 8

Analysis of Soil of Cultivable Land between Kharga and Baris

	0-20 cm.	20-40 cm.	Mechanical analysis	0-20 cm.	20-40 cm.
Saturation capacity %	= 22.45	40.77			
Carbonate content %	= 3.77	1.92	Coarse sand %	= 58.8	9.04
Total soluble salts %	= 0.20	1.34	Fine sand %	= 29.6	46.04
Conductivity (millimhos)	= 0.5	2.05	Silt %	= 3.0	6.0
Chlorides (m. eq.)	= 0.28	0.89	Clay %	= 3.0	34.0
Sulphates (m. eq.)	= 8.58	17.17			
Organic matter %	= 0.019	0.09			
*p*H	= 8.2	8.0			

Wadi Baris is a fertile valley extending between kilos 75 and 90 along Kharga-Baris Road. The total area of cultivable land in that valley is 35-40 thousand acres. The soil is clayey and deeply cracked in most parts. In some parts the clay is covered with a thin layer of sand. The plain can readily be changed into cultivated land if new wells are drilled in order to increase the water supply.

In Baris area and around Baris village there is a number of old wells one of which is Ain Tafnees already referred to. In addition to these there are two modern wells belonging to the government, namely, Baris wells Nos. 1 and 2. The former has a discharge of 150 kt. sufficient to irrigate 300 acres. The water is of a good quality, with low salinity but with some lime in it. At present the water output of the well is in excess of the irrigation needs of the area prepared for cultivation, and the extra water is led to a depression (Pl. V, B) in which it collects to form a pool of stagnant water. Such procedure implies wastage of water and increases the salinity of the soil. Development of new cultivable land should precede the drilling of new wells, so that all the water discharged could be utilised. At the same time the wells should be so constructed as to be possibly opened and closed at will.

At the time of our visit two farms were cultivated on Well No. 1, mainly with wheat and partly with barley. Owing to dryness of the soil and high evaporation, irrigation is made at very short intervals of 3, 8 or 10 days.

Baris Well No. 2 is about 3 km. south of the village.

Cultivated Land in Dakhla Oases.

Between Kharga and Dakhla three fertile cultivable wadis are met with, namely, Wadi El Zayat, Wadi El Belezieh and Wadi El Akola. The first of these is a wide flat expanse of fertile land, with cracked heavy clay soil. It lies midway between the two oases, and starts at Km. 92 from Kharga, extending till Km. 105. It is quite barren owing to lack of water. If artesian water could be obtained in that wadi it can be possibly cultivated and would then make an important addition to the area of cultivated land in the new valley, i. e. the oases. Wadi El Belezieh starts at Km. 140 from Kharga, 12 Km. east of Teneda. It is also barren because of lack of water. Wadi El Akola is a sandy plain at Kilo 150. It derives its name from Akool (*Alhagi maurorum*) which grows abundantly in that area. Associated plants are tamarisks, especially on the hills. *Acacia* and date palm are also found in some places. The vegetation is rather dense. The wadi lies at the southern extremity of Dakhla depression and receives its water supply from the water spilled out of the wells of Dakhla and seeping southward.

There is also cultivated and cultivable land between and round the villages of Dakhla. In each village there are private fruit gardens and cultivations of crop plants. In many places, specially round Mot and Gedida, water is spilled causing the formation of salt marshes and highly saline land. On higher, fertile, less saline areas wheat, barley and clover are grown successfully in winter, while rice and maize are grown in summer. Other crops and vegetables, such as beans, peas, lentils, onion, garlic, radish, marrow, Jew's mallow (*Corchorus olitorius*), Capsicum and tomatoes are also grown though on a smaller scale. The chief fruits grown in Dakhla are oranges, dates, grapes, olive, fig, banana and Opuntia. The fruits, though of excellent quality, are not produced on a commercial scale, and are hardly sufficient for private consumption.

Formerly, there were more than 900 wells in Dakhla. The number is gradually decreasing since some of the wells are being overwhelmed by drifted sand. Most wells, specially those of Kasr, discharge hot water. Recently, the government has drilled a number of new wells with a big

discharge, at the rate of one well for each village. In some of the wells of Dakhla, water rises with force above the surface of the ground, in others it does not reach the surface and so is raised by primitive means. This is specially the case in villages found at a high level, e. g. Bedkhoulo, Rashda and Kasr.

In Dakhla the total area of cultivated and cultivable land utilising the present water resources is more than 40,000 acres. This area can be greatly increased through increase of the water supply by drilling new wells to deeper water-bearing strata.

Several weeds are found in the cultivated lands of Dakhla Oasis. The commonest weed is *Asphodelus tenuifolius,* which is found everywhere on moist soil, and specially on the banks of irrigation canals. Other weeds are *Calendula micrantha, Convolvulus arvensis, Eruca* sp., *Astragalus* sp., *Melilotus indicus* v. *bonplandii, Trigonella laciniata, T. hamosa* and *Salix safsaf.* The last-named plant is very common round the wells.

The village of El Kasr is 38 km. north of Mot. It lies on a ridge within an area of rocky hills and sand dunes. It does not have a low fertile valley in its vicinity like all other villages of Dakhla. Irrigation water is lifted from the wells by means of primitive instruments. Dunes encroach upon the village from the north, while patches of cultivated land are found on the north, south and west. Many wells have been overwhelmed by the wind drifted sand, and consequently the water resources of El Kasr are now rapidly diminishing. Water has decreased from 45 to 15 kirats. Extensive areas that were formerly under cultivation are now getting barren because of shortage of water.

Between Kalamoun and Mot there is a very wide alluvial plain which can readily be cultivated if a supply of irrigation water is secured. Present partial cultivation of this plain depends on a new well, lately drilled by the government, known as Kalamoun Well. The well is at a higher level than the surrounding plain, and its presence has led to marshy conditions in the surrounding area.

5. *Salt Marshes and Saline Lands.*

Salt marshes are widely distributed in all the oases of the Western Desert. Marshy conditions are brought about by uncontrolled spilling

of water and flooding of the plains. Under the prevailing conditions of strong evaporation and lack of drainage, such flooding of the soil with the slightly saline artesian water increases its salinity so rapidly that fertile land soon deteriorates and changes into waste saline land. There are salt marshes in nearly every village, occupying the water-logged depression near the wells. In saline areas which are not flooded the water table is close to the surface.

Salt marshes usually support a dense vegetation of halophytes and marsh plants. The following examples of the salt marsh habitat may be given :

Mot salt marshes.

At the outskirts of Mot, the principal village in Dakhla Oases, there is an extensive area of flat saline land, covered with a crust of salt. The high salinity is referred to spilling of water from the wells and inundation of the plains. There is a fence of *Tamarix* trees bordering that saline area. The salinity is so high that no vegetation is supported at all. Soil samples were collected for analysis (Table 9). The salts are mainly sodium chloride and gypsum. The water capacity in the two stands is relatively high. The soil reaction is neutral in one of the stands and alkaline in the other.

TABLE 9

Analysis of Soil from Two Stands in a Salt Marsh near Mot

Surface :		Stand I	Stand II	Mechanical analysis		Stand I	Stand II
Saturation capacity %	=	43.61	48.32	Coarse sand %	=	14.8	15.9
Carbonate content %	=	4.96	1.11	Fine sand %	=	42.4	5.2
Total soluble salts %	=	28.0	61.4	Silt %	=	3.6	6.0
Conductivity (millimhos)	=	86.7	175.0	Clay %	=	3.4	2.0
Chlorides (m. eq.)	=	259.0	630.0				
Sulphates (m. eq.)	=	152.29	306.9				
Organic matter %	=	0.89	2.21				
*p*H	=	7.0	8.4				

Kalamoun salt marshes.

The low plain around the new Kalamoun well (Pl. VI, A) is inundated and supports a stand of *Zygophyllum coccineum,* having the following composition :

Zygophyllum coccineum	d
Tamarix arborea	ab
Colocynthis vulgaris	c
Juncus acutus	c
Cressa cretica	c
Asphodelus tenuifolius	c

There is a crust of salt on the surface of the ground in higher parts and free water in lower parts. The total plant cover is 50 %.

Zygophyllum grows vigorously, reaching a height of 50 cm. and a diameter of 1.5 m. *Tamarix* dominates in some localities. *Colocynthis vulgaris* is found on higher, relatively dry, areas. *Juncus* and *Cressa* occur in highly saline parts.

Gedida salt marsh.

To the north-east of Gedida village there is a big salt marsh (Pl. VI, B) in a depression surrounded by private gardens and cultivations of wheat and other crops. The latter are found at a higher level than the salt marsh, and in their turn are followed on the northern side by sand dunes at a still higher level. The soil is sandy. In the lower parts of the sandy depression, which are usually waterlogged, grows *Scirpus littoralis,* associated with *Scirpus maritimus* and *Juncus acutus.* On the saline slightly elevated patches of ground scattered in the salt marsh and at its periphery, grows *Tamarix.* In these patches the soil surface is covered with a crust of salt. *Alhagi maurorum* is abundantly found while *Cynodon dactylon* and *Cressa cretica* are very common. In the water there is a rich algal flora.

The percentage cover is about 30 %. A soil sample was collected for analysis, and the results are presented in Table 10.

In Table 11 is also given the analysis of a saline soil at Bulaq.

TABLE 10

Analysis of Soil from a Salt Marsh Near Gedida at 10 — cm. Depth

		Mechanical analysis	
Saturation capacity %	= 23.13	Coarse sand %	= 25.9
Carbonate content %	= 3.7	Fine sand %	= 59.4
Total soluble salts %	= 1.3	Silt %	= 3.1
Conductivity (millimhos)	= 2.4	Clay %	= 3.0
Chlorides (m. eq.)	= 5.21		
Sulphates (m. eq.)	= 10.73		
Organic matter %	= 0.09		
*p*H	= 7.0		

TABLE 11

Analysis of Saline Soil at Bulaq

		(Soil surface)	Mechanical analysis	
Saturation capacity %		= 38.58	Coarse sand %	= 10.0
Moisture content %	0-25 cm.	= 5.68	Fine sand %	= 14.7
	25-50 cm.	= 0.32	Silt %	= 2.0
Carbonate content %		= 4.45	Clay %	= 22.0
Total soluble salts %		= 44.34		
Conductivity (millimhos)		= 132.6		
Chlorides (m. eq.)		= 639.8		
Organic matter %		= 1.215		
*p*H		= 8.7		

6. *Aquatic Habitat.*

The aquatic plant communities of the oases have been studied by Oliver and his assistants in 1930-1931 and later by Hassib (1951). Both authors discovered a rich aquatic flora in the pools, wells and irrigation canals. There are several species of blue-green and other algae. Of the higher plants the following species are recognised : *Utricularia exoleta, Potamogeton pectinatus, Ruppia maritima, Zannichellia palustris, Najas graminea, Lemna gibba, Nitella* sp., and *Chara* sp. *Typha, Phragmites, Nymphaea* and *Veronica* also occur in little streams and wet meadows. *Ruppia* and *Zannichellia* are specially found in the salty pools, while the floors of these pools are carpeted with *Chara.*

Oliver (1930-1931) was impressed by the richness of the aquatic flora. He wondered whether such rich flora might not be the direct survival of a more ancient flora deriving from the days when the oases had a moister climate than now, and might even have contained lakes. The desert aspect is possibly more recent than the aquatic aspect.

CONCLUSION

There are vast areas of cultivable land in the oases, capable of reclamation and cultivation. These areas are flat plains, with fertile clayey, loamy or sandy soil. When fully utilised they will form an appreciable addition to the total area of cultivated land in Egypt. What is needed for their full utilisation is, in the first place, to increase the water resources by drilling a sufficient number of new wells and raising water from new water-bearing strata.

The cultivation practiced by the oases inhabitants is still primitive and unprogressive. There is every possibility for improving the agricultural practice on the basis of investigating the various problems involved. The present authors are of the opinion that extension in the production of different crops should proceed at different rates and that preference should be given to the fruit trees. The fruit products in the oases are of excellent quality, yet fruit growing is quite unorganised. Isolated trees of the various fruits are grown in private gardens. All cultivated fruits are capable of extended development. There are unlimited potentialities for fruit farming, far in excess of the present production. Fruit farming has also the merit that fruit trees have a lower water requirement than the ordinary field crops. In their irrigation it is unnecessary to flood the soil with water, and so exposure of a free water

surface to direct evaporation and the consequent accumulation of salts in the surface soil is avoided. Water could be applied to each tree separately by pouring into a relatively small hole round the tree. The soil surface in the hole can be protected from direct evaporation by various means, such as a cover of small pebbles, coarse sand or plant litter.

Increased production of vegetables and field crops should not be carried too far unless proved successful. Irrigation of these crops, and especially of the staple cereals of the Nile Valley such as wheat, barley and rice need inundation or heavy irrigation and extravagance in the use of water. Such inundation causes deterioration of the soil through increasing its salinity. Investigation of the water requirement of various crops and various strains of each crop should be made, and preference for propagation in the oases should be given to the crops with the smaller water requirement.

Reclamation of land for cultivation in the oases is confronted with the following major difficulties :

1. *Sand Movement.*

Much has been said in the text about the nuisance caused by drifted sand to the inhabitants of the oases. It causes erosion in some places and overwhelming of villages, wells, cultivations and irrigation channels in other places. The problem of sand control under the drought conditions of the oases must be carefully studied, and recent scientific methods of protection against drifted sand must be applied. Experiments should be made for testing the suitability of various species of plants, particularly of trees, for use as living windbreaks and as stabilisers of mobile sand dunes. A special supply of water must be secured for the establishment of protection belts of plants.

2. *Salinisation.*

Progressively increasing salinity of the soil causes its rapid deterioration. Many of the areas that were formerly under cultivation in the oases have changed into waste saline land supporting halophytes or xerophytes, or into salt marshes supporting marsh plants. Such change is brought

about by continual heavy irrigation of the cultivated land under conditions of intense evaporation. It is also brought about by the spilling of water from the wells, so that for a considerable distance around each well the soil is wet and saturated, and marshy conditions prevail.

As a solution to this problem the discharge of water from the wells must be strictly controlled, and wells ought to be possibly closed when water is not wanted. Saline areas surrounding the villages and wells could be reclaimed by growing rice in them for a number of successive years. Rice is a water-loving crop which can grow in salty places. Through cultivation of this crop the salts in the soil become well soaked and dissolved. They can be washed away into deep drains constructed for the purpose. Another precaution is to minimise the spreading of water on the soil surface during irrigation and to grow in the oases only such plants that have the smallest water requirement.

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A

A barchan at Ganah with a sand plain protected on the north by mobile dunes and on the east (right side of the background) by stabilised dunes.

B

A stabilised sand dune at Ganah. The dune is covered with *Tamarix*. The plant parts are densely branched within the mass of sand. On the leeward side there is a tapering tail made of recently deposited sand which is not yet stabilised by vegetation.

A

Sand dunes overwhelming doum and *Balanites* trees near Baris (Kharga Oasis).

B

A stand of *Zygophyllum coccineum* associated with other plants in an area of waste land south of Kharga village (Stand 1).

A

Another stand of *Zygophyllum coccineum* (Stand 2, east of the road), also representing the vegetation of the waste land between Kharga and Ganah.

B

A waste land community north of Ganah dominated by *Sporobolus spicatus*. Note that the vegetation is relatively dense (total plant cover about 70 %).

A

An area of waste land supporting *Alhagi maurorum*, *Balanites aegyptica*, doum palm and other plants. The area was formerly a millet field.

B

A wheat field at Baris. Note the vigorous growth of the crop.

A

The new well drilled by the Desert Reclamation Service at Kharga village. Note the irrigation channel conducting water from the well to the farm.

B

The stagnant pool in which the extra-water discharged by Baris well No. 1 is stored.

A

Bir El Kalamoun, recently drilled by the Desert Reclamation Service. Note the salt marshes surrounding the well.

B

A salt marsh to the north east of Gedida village in Dakhla Oasis. Note the dense growth of *Scirpus, Tamarix* and *Alhagi*.

SUBSIDIARY INCOMES AND SECONDARY ECONOMIES IN MISHLA COMPLEX

BY

KAWTHAR ABD EL-RASOUL

The complex of Mishla is a rural area situated on the right bank of the Rosetta Branch of the Delta of the Nile, some 10 kilometers to the south of the industrial center of Kafr Ezzayat. The whole complex has an area of 11.9 square kilometers, that is the equivalent of 2830 feddans. It is roughly bordered by the Nile to the West, and by a line which partly run along the Neʿnaʿiya canal and partly along the railway which connect Kafr Ezzayat with Minuf to the East. Its total length may cover some five kilometers, while the breadth reaches some two and a half kilometers.

This covers the cultivated area of the two big rural centers of Mishla, which according to the returns of the 1947 census [1] has a population of 4664 persons, Kafr Mishla with a population of 1948 persons, and the adjoining small settlements; Amir Hassan with 53 souls, Ezbet Mohey Eddin with 9 persons, Ezbet Mohamed Sieʿeb El Arabi with 40 persons, and Ezbet Mohamed Abu Selim with 18 persons. The cultivated area of Mishla include 8.2 square kilometers or about 1950 feddans, thus it has a density of 576 persons per square kilometer. Kafr Mishla has an area of 3.7 square kilometers or 880 feddans, thus the population density approaches 526 persons per square kilometer.

One must not think that these figures are very characterising of the Mishla complex for this is the picture of nearly all the Central Delta; small cultivated surface and a high density of population.

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[1] General Census of Egypt, 1947, tract 14, Munufia Province, pp. 7-228, and tract 13, Gharbia Province, pp. 13-155.

The main economy of the Mishla complex is naturally agriculture, and the village types in the area are essentially rural. The following table may give an idea about the structure of economy and occupations in the whole complex. Figures are derived from the 1947 general Census [1], while the given percentages are computed by us :

Population Categories and Occupations	MISHLA		KAFR MISHLA	
	PERSONS	PERCENTAGE	PERSONS	PERCENTAGE
Total population	4726	100	1948	100
Male population	2304	48.75	952	48.87
Female population	2422	51.25	996	51.13
All male over 5 years	2030	100	842	100
Occupation by male :				
Agriculture [2]	1437	70.8	635	75.4
Transformative industry [3]	50	2.4	—	—
Commerce	60	3.0	11	1.3
Public and private services [4]	85	4.2	35	4.2
Building	7	0.3	—	—
Transport	6	0.3	—	—
Unproductive occupation or not clear	152	7.5	54	6.4
unemployed	233	11.5	107	12.7

[1] *Ibid.* For Mishla tract 14, p. 76, and for Kafr Mishla tract 13, p. 155.
[2] Under the heading Agriculture, the census counts land cultivation and land owning, rearing animals and birds, and fishing.
[3] Under transformative industries the census counts grinding corn, oil and soap fabrication, carpentary, weaving with no specialisation, boat building, etc...
[4] Under public and private services the census counts hotels, café houses, medical service, teaching, police, clergy, administration, etc...

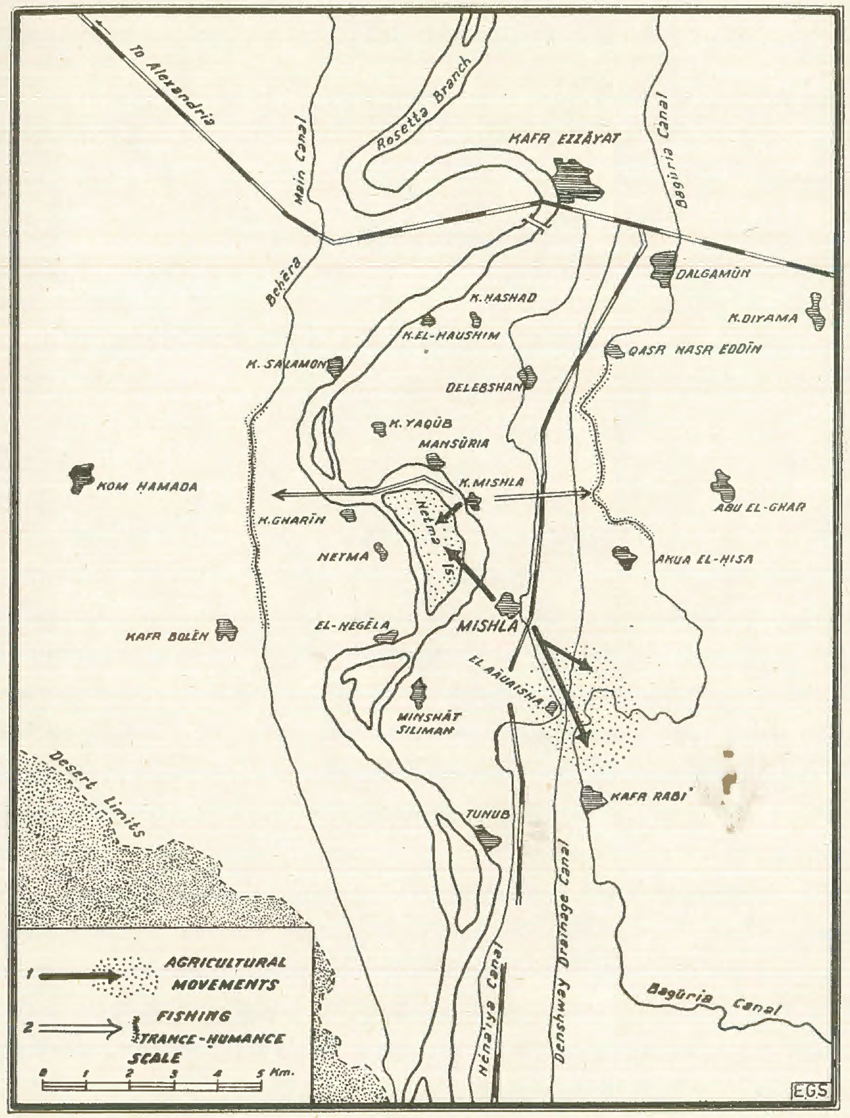

Fig. 1. Mishla and Surroundings.

1. SUBSIDIARY INCOMES.

A) *Agricultural Tarahil.*

Tarahil means temporary contracted group labour. This, however, does not include at all any compulsory work; on the contrary it is voluntary, and every person can negotiate with the contractor alone, and quit the work whenever he wants. The agreement between the contractor and the workers is but oral, not valid over a year or more but its validity is condition by the season. Neither the contractor, nor the labourer pay any compensation if the agreement is broken from that part or the other. Although there are specialised contractors, there is no hypothitical body or frame which can be called a class of labourers; there are peasants with very small holdings or no holdings at all who sell their labour nearly on a basis of daily wage either to augment their income or to earn their living. Though a group of workers can unite to force the contractor to raise their payement, there is no organisation such as a union for the labourers. Neither there is any such union for the contractors who depend totally upon the whims of the administration of the agricultural estates. This state of affairs is enhanced by the very qualities of such agricultural labour; temporarity of the work, freedom on both contractor and workers side to break the agreement at any time without any legal consequences, lastly the unskilled character of agricultural labour.

We have hinted that furthering one's income or earnings one's living are motives for a tarahil worker. Among other motives we may stress the presence of big land holdings which necessitate much working hands, especially in what concern crops which need special care, such as cotton which need so much work in planting, irrigation, hoeing, weeding, combating pests, collecting the cotton after it ripens, etc.

The organization of agricultural tarahil may be described as follows :

1. *The Contractor :* In the complex of Mishla there are 5 contractors for agricultural tarahils. A contractor may own or may not own a piece of land, but it is considered that his main job is recruiting workers for the tarahil. Each contractor has his special sphere of influence, and all of them work in a complementary way owing to the needs of the big estates which surround the complex. Competition is thus reduced to the minimum. A contractor's earning is a percentage of the wage to be paid to the workers. This is computed separatly and the workers do not know the exact sum paid by the administration of the estate to the contractor for each worker. Any how the workers argue with the contractor nearly every day about their daily wage. In this way we can see that the percentage is not similar every day and all depend upon the cleverness of the contractor on the one hand and the necessity of the worker on the other hand. But there are seasons which demand as many workers as possible, and fear of competition may lead either to a gentleman's agreement among the contractors to fix the prices or to the success of the workers to impose the maximum possible wage. However, the percentage of the contractor is something around 5 percent on the public records, and is certainly higher in reality.

2. *The Workers :* Those fall in three categories, namely children under 12, children under 16, and men over 16. To each category there are special assigned kind of work.

Children of both sex between 6 and 12 years old are entrusted with weeding picking up all unnecessary roots and weeds which will harm the growth of the crop, and collecting potatoes. Their daily wages will attain between 6 and 8 piasters during the season of intense work, while will decrease to under 5 piasters in normal seasons. Children of both sex between 12 and 16 years, and women of any age are assigned to more heavier tasks, e. g., spreading fertilizers over the fields, collecting cotton, or packing potatoes. The mean daily wage of this category varies between 10 to 12 piasters in the season of intensity, and falls under 10 in other seasons.

Men over 16 years are assigned more specialized work, such as ploughing, planting, irrigating, hoeing, etc. Their daily wage varies between 12 and 15 piasters, and falls under 10 in normal seasons.

3. *Wage :* We have already refered to the wages of every category of workers, but we may add here that some proprietors do not pay on a

daily basis, but payment is regulated on the basis of production. This may be appropriate as to collecting cotton or wheat per sack or feddan.

Wage is not paid all in cash, but the contractors revert to a method by which they keep their hold over the workers. This is accomplished by letting the family of the worker to draw their grocery demands from a special shop on account. Thus nearly all the wage is paid in commodity and any worker who desert the work is instantly prevented from drawing anything from the shop.

The fluctuation of wage is necessitated by the rotation of agricultural work in the Delta. One can detect at least two seasons of intense field-work, the first of which falls between April and June, while the second occupies the monthes of September and October. This means that there are two inter-seasonal periods in which the demand on workers is not high, even low or lacking, especially in what concerns the acreage under fruits. The first intense season include harvesting wheat and potatoes, threshing wheat, irrigating and ploughing the fields for planting either maize or cotton, weeding, and hoeing. The second intense season include collecting cotton as the main job. In between is a short season of combating cotton pests by picking the infected leaves and spraying the fields with chemical stuffs.

Examples of the per feddan necessary working hands are as follows : planting potatoes 4 men. Hoeing potatoes 4 men (hoeing is done three times), weeding 10 children, and picking and packing potatoes about 40 men and children. For cotton hoeing (executed three times) needs 6 men, weeding 10 children, spreading fertilizers 10 children, picking infected leaves 10 children and 15 children for collecting cotton.

4. *Other Preparations :* Transport or food or lodging are all the responsibility of the workers, since the estates in which they work are very near to the Mishla complex. Impliments for hoeing and weeding must be provided by the workers.

5. *The field of work :* There are three places to which the agricultural tarahil of the complex are directed :

a) The island of Netma, usually called by the people Island of the Wakf. This island contains about 800 feddans, of which the government

cultivate about 500 feddans. The workers here come from three directions; from Kafr Mishla, from Mishla, and from Netma on the other side of the Nile. The workers from the complex of Mishla constitute more than half of the workers; about 40 children and men daily from Mishla, and a little bigger number from Kafr Mishla. The work on the Island is not so intense in comparison with the land of the Delta owing to the fact that the soils are lighter and somewhat sandy. A great part of the island is specialized in fruits, e. g., banana and water melons thus the work is virtually interrupted during some monthes of the year.

b) The estate of the Hassaina. A big estate to the south and south-east of Mishla and contains about 500 feddans. Many tarahil work on this estate, but its northern part is exclusive for the tarahil of Mishla. The soil is hard, and small portion is under fruit cultivation. This means that the need for workers is practically all the year round. In seasons of intense work there are as much as 200 workers from Mishla are recruited and this number decreases to 100 only in normal seasons. The policy of the administration of this estate is directed towards keeping as much as possible of the workers on the fields, even when work is less, to give a continuous means of living for the workers, but the only condition is that their wages are much reduced.

c) Rice fields in Northern Delta : This is more directed to the rice fields of the Kafr Esshiekh province in the praries of the Northern Delta. In this case the individuals who work on the rice fields take an absence of some two monthes from Mishla, and help in planting and harvesting the crop. The daily payment may reach the sum of 15 piasters plus lodgings and food which are provided by the owners of the fields. It is evident that the workers, though few in number, prefer this kind of tarahil owing to the generosity of the land owners, the daily fish and rice dish which they partake with the family of the owner, and other conveniences which are provided to them. It appear that no contractor is directly responsible for the rice tarahil, for the workers disperse individually among different families. Some of the payment is also given in rice which the workers sell when they return of Mishla complex.

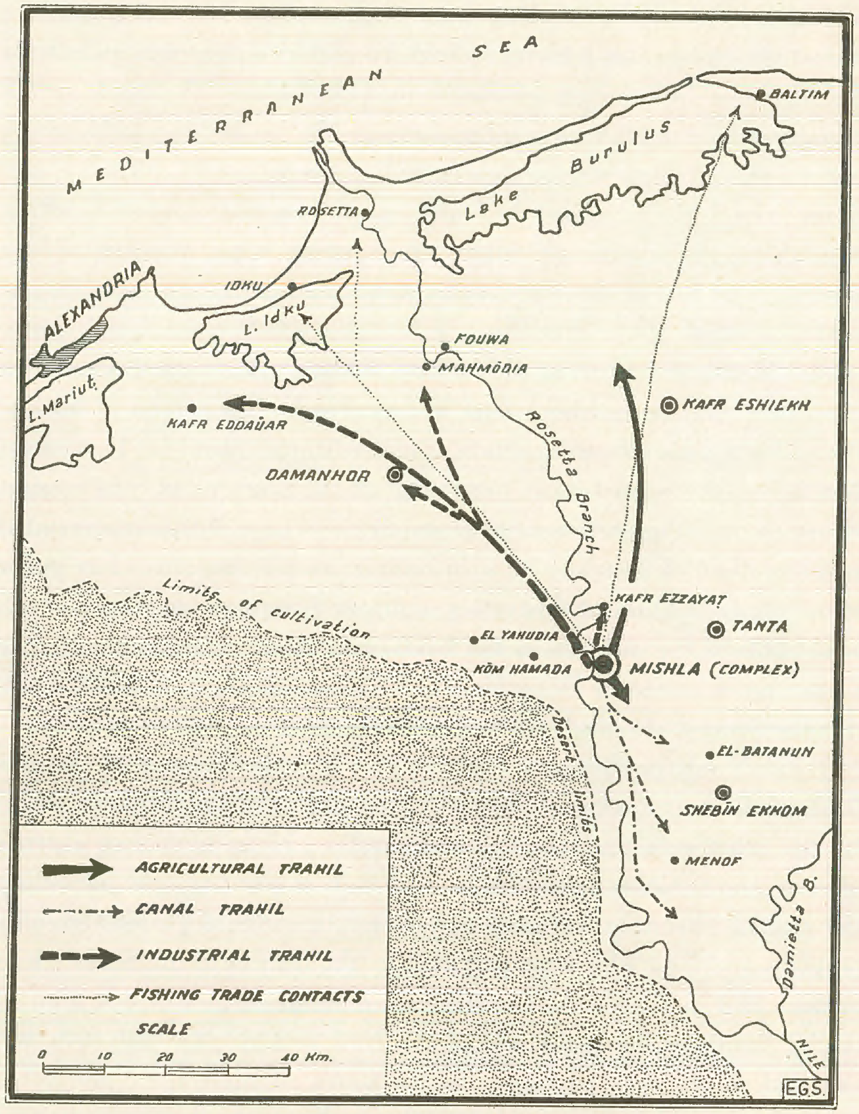

Fig. 2. Mishla Complex.
Subsidiary Economy and Seasonal Movements.

B. *Non-Agricultural Tarahil.*

Non-agricultural tarahil fall in two categories; canal tarahil and industrial tarahil :

a) *Canal Tarahil :*

This includes either digging new canals for irrigation or drainage, or clearing the beds of such canals from the silt which accumulates every year. There is one contractor for such a work in the complex of Mishla. This job is a governmental one, and the government takes the lesser bid for accomplishing the job in each district alone. The big contractor will ask the local contractors to provide him with the necessary workers. Thus the real wage of the worker is much reduced owing to the fact that at least two contractors take their percentage from the wage of the labourer. Cost of transport is added on the expenses of the wage, thus the daily wage reaches a figure under 15 piasters. It has been found that many workers desert their jobs after a certain time if the place of work is too far from the village, so the contractors try their best that the work should be confined to the limits of the area to eliminate the possibility of running away. This has the advantage of solving an important problem, namely lodging and provisions. If the canals are far from the village the workers has to sleep in tents or in the fields and some reports on theft were frequent in such circumstances; being strangers may give the workers motives for such a behaviour. This is reinforced by the fact that their provisions always run short, and their money too, because they are paid in the same way described above. Most of the work is done on the canals in and around the Mishla complex, e. g., the canals of Ṭomania, Danshuai, Khalig el-Naḥarin, and Neʿnaʿiya. But some works are done also in the districts of Tala and Menuf of Menufia province. The number of workers engaged in the local canals varies between 50 and 100, while that of the canal working outside the locality may attain from 30 to 50 workers. The work is always done in winter, in what is known as «Sidda Eshetuiya» = meaning the winter blocking of the canals. Sometimes work is done in the small

canals in summer, but owing to the fact that many field works are to be done at that season, the wages of such tarahil are higher than that of winter.

b) *Industrial Tarahil :*

The tarahil movements in this respect take three main directions; to Kafr Ezzayat, to Mahmudia, and to the area of Kafr Eddauar.

(I) The movement to Kafr Ezzayat include some 50 workers all of whom work in the factories of cotton ginning. The work in unskilled, consequently the workers are engaged mainly as carriers. Most of the workers are men, but a small percent consist of children who help collecting and carrying small burdens inside the factory. The daily wage for 8 hours work is about 25 piasters. This is considered a good bid, but it is known that this relatively high wage compensate for the harm which may be done to the lungs of labourers in cotton ginneries. Lodging is provided by the owners of the factories, because it does not cost them anything; the workers are welcomed to sleep in the courtyard of the factory. Some tarahil from the complex of Mishla find their way to cotton ginneries of Damanhur, where the same conditions as that in Kafr Ezzayat prevail with the exception that the wages reach some 35 piasters. This may be due to the fact that a higher bid in Damanhur is necessitated by the fact that Kafr Ezzayat is so near to the Mishla complex, so that expenses of transport, and the possibility of visiting the family as frequent as possible during the period of the tarhila—November to January—has to be compensated to attract labour to Damanhur. The comparatively smaller density of population in Behera Province (of which Damanhur is the capital) may add a clue to explain the higher wage in Damanhur.

(II) The movement towards Mahmudia include about 20 persons who work also as carriers in the brick factory of Khorshid. Only men between 20 and 40 years are accepted in this tarhila. The period of work covers 25 days and the payment of 300 piasters for the whole work is paid lumpsum at the end of the period. Transport costs from Mishla to the factory are devided between the labourer and the factory in two halves. The 8 daily working hours can be augmented by another 4 hours paid as the normal hour is paid. Lodging takes place in the courtyard of the factory. The workers take with them their provisions of bread and pickles, while they buy vegetables from the vicinity and cook it collectively.

(III) The movement towards Kafr Eddauar include also some 25 persons who work in brick factory of Marco near the town of Kafr Eddauar. The same conditions just described above prevail also in this factory. In the area of Kafr Eddauar there are also some factories for preparing the onions for export. To this factory some tarahil of the Mishla Complex are directed, but instead of the work being exclusively for men, it comprises the two sexes. The girls of Kafr Mishla take the bigger share in the onion tarahil which may include some 200 of both sexes. Lodging and provisions are done in a similar way as previously described, but the daily wage is considerably less; it reaches the sum of 10 piasters. The duration of this tarahil may attain from two to three monthes.

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* *

A glance at the accompaning maps will convoy to the reader a quick idea about those different tarahils and their geographical orientations.

2. SECONDARY ECONOMIES.

A) *Fishing.*

Though agriculture is the main occupation of the whole complex of Mishla, including Mishla and Kafr Mishla, it is in the last named village that we find considerable fishing activities. Of all the complex of Mishla, Kafr Mishla is the only village situated directly on the Rosetta branch of the Nile's Delta, while the village of Mishla is situated some 600 meters to the east of the great water course. It may be safely assumed that the relative positions of the two settlements as to the Nile has affected the orientation of the people and their economic activities. It is a fact that these slight space differences has been responsible for the lack of fishing tradition in Mishla, but such a reasoning—depending totaly on geographic location—must not be pushed too far. As we will see below, the Baguria

canal—one of the main irrigation canals in the middle Delta—provides the fishermen of Kafr Mishla with a good fish output in special seasons. The village of Akua el-Ḥisa lies on the banks of Baguria canal, yet fishing is lacking in Akua. After my investigations in Kafr Mishla it was discovered that the ancestors of the most important fishing family comes originally from somewhere in Giza Province, i. e., not aborigins of the Mishla complex. This fact may prove, along with geographic location, that human and cultural elements played the bigger role in founding a tradition of fishing in Kafr Mishla.

Fishing Community : Of the whole population of 1948 souls in Kafr Mishla only about 80 persons depend on the fishing economy. Not all this number is actually employed in fishing for this number includes wives, children, and old people of the fishermen. Of this number 27 men plus some 15 boys are engaged in the occupation. As we shall see below their are 15 boats in Kafr Mishla, and each boat is manned by a crew of two men and a boy.

Though the number of fishermen and those depending on them and on fishing income appear to be insignificant either absolutely speaking or in proportion to the population of the village and so are the numbers of all other handicrafts, it is yet very important. This importance is derived from the fact that this fishing community present us with an all reversal of the economic picture in the whole complex of Mishla; to them agriculture is a secondary economic activity and provides them with subsidiary incomes!

The majority of the fishing community is composed of individuals belonging to two families, while the rest of the community belong to four different families. The two important families are the Malayga and the Khalayfa. The Malayga count about 30 souls and are by far the most important fishing family in Kafr Mishla. They are not originally from the village but have a history of three generations in Kafr Mishla. Aly el-Miligy, the great grand father of the present generation came from the village of Milig in Giza Province. His son Hasan el-Miligy was a well known fisherman in Kafr Mishla, so it is assumed that he inherited this profession from his father. Mohamed el-Miligy, son of Hasan, was

also a fisherman but he is now old and inactive. His sons and grand sons, who count about 30 souls are the fishermen of the family. The malayga are self sufficient in what concerns the number of professional fishermen. They provide eight men and eight boys to their boats and do not hire any extra labourers as the other fishermen do. This fact is a salient evidence as to the inherent qualifications of the Malayga as real fisher folk. Another evidence is that the Malayga own but very few acres; actually one of them own half a feddan! But they cultivate the narrow strips of land which the Nile uncovers during low waters in winter, which is hired from the government, and known in Egypt as TARḤ BAḤR land.

The Khalayfa is known to be an old family in Kafr Mishla, and the branch of this family which lives on fishing does not exceed 25 persons. They provide six professional fishermen for their boats and a similar number of boys, but they hire other working hands according to the intensity of the fishing season. It is well known in the traditions of Kafr Mishla that this Khalayfa branch took to fishing only 40 to 50 years ago. From the historical sequence one can safely assume that the tradition of fishing in Kafr Mishla as a primary occupation for a certain part of its population does not exceed one century and began after the arrival of the Malayga family to Kafr Mishla. One can also assume that a branch of the Khalayfa family has taken to this new occupation due to unidentifiable reasons among which we may count poverty, and perhaps was taught this occupation by the malayga. Other branches of the Khalayfa own cultivated land, but the fishing branch cultivate TARḤ BAḤR land much as the Malayga do. This fact asserts our above mentioned statement that the Khalayfa are considerably younger in fishing tradition than the Malayga. The same fact applies to the other individuals who are at present engaged in fishing. These include a member of Madkur family which is one of the big families of Kafr Mishla and from which the mayor of the village was elected since some generations. This person owns two boats and hire as much as four men and two boys to handle his boats. Three other individuals from three different families own their boats and hire wage labour according to the intensity of the fishing season.

Boats : In Kafr Mishla there are 15 boats engaged in fishing activities and are divided among their owners as follows :

6 boats are owned by the Malayga,
4 boats are owned by the Khalayfa,
2 boats are owned by Hamed Madkur, and
3 boats are owned by three other persons.

All the boats are equiped with both a relatively small sail and oars. Sails are seldom used except during the flood when the current is strong. These boats, which are called FELŪKA, rarely exceed six meters is length. In Kafr Mishla there are no specialists in building the boats and it is the custom that the boats are either built in the village of Qasr Nasr Eddīn and Rosetta or more often the carpenters are hired to do their job in Kafr Mishla itself. Usually a boat is manned by two men and a boy, but some times its crew decreases to one man and one boy, or increases to four men and two boys. This variation is necessitated by the various methods and fishing equipment used according to circumstances. However, the boy is always engaged in directing or rowing the boat while the man or men take care of the nets.

Fishing implements and nets :

Fishing implements are confined to hooks and nets. Hooks are fixed in a rope of a considerable length and let in the water from the boat. Though hooks are used yet nets play the important role in fishing, and range from the small net which is spread out by the hand from the shore, and called TARRAHA, to nets which attain great dimensions. Of the last named three kinds are widely used in Kafr Mishla known as HARBA, ṬAKIN and HABLA.

The HARBA is a relatively wide-holed net and has a total length of about 140 meters while the breadth is 20 meters. It weights 90 pounds and costs about 40 Egyptian Pounds plus some 6 Pounds for the rope and cork. No fisherman can afford alone to buy the Harba, and it is the custom that four fishermen share the price and its use together.

The ṬAKIN is a triple net, knitted to each other at the ends. The two outer nets are wide-holed while the middle net is a very narrow-holed one. The total length reaches about 200 meters but the breadth does not exceed 1.5 meters. The whole net is made of very fine cotton, and only weights five pounds. The Ṭakin is the cheapest of all three kinds of nets, for it costs no more than 10 Egyptian Pounds.

The HABLA is comparatively smaller in dimensions than the previous nets because it is 30 meters by 80. It is also a narrow-holed net, and weights about 30 pounds. Its total price reaches the amount of 18 Egyptian Pounds.

All these kinds of nets are not made in Kafr Mishla, but bought ready-made from bigger fishing centers around the lakes of the Northern Delta. The nearest center to Kafr Mishla is Idku on lake Idku, and the fishermen of Kafr Mishla has a greater trade contacts with this center than any other. Still they have trading contacts with lake Burulus, and weak contacts with Damietta.

Fishing methods : The three types of nets already mentioned have different properties and different qualifications as to the way of use and the type of fish to which it is adjusted. This may be summarised as follows :

a) Fishing with the HARBA needs one boat with a crew of four men and two boys. It also needs special physical conditions which are to be found in the many river bends around Kafr Mishla. When the course of the river curves it is usual that one side will be shallow while near the other side the bed of the river will attain its maximum depth. These conditions are exactly what is needed to fish with a HARBA. The boat begins from a point on the shallow shore where one of the four men will be left with the end of a long rope. The boat proceeds in a direct line across the river and turn at right angles when it arrives at the deeper water. From this point onwards the crew will let down the net while the boat proceeds parallel to the shore. When the whole net is let in the deep water—a distance of about 140 meters or the equivalant of the length of the net—the boat make another turn at right angles and

proceed towards the shallow shore where another man lands, holding the other end of the rope. The two men with rope ends begin to pull the rope and simultaneously move in the direction of each other. In this way they drew the net towards the shallow bed of the river and at the same time let the ends of the net curve inwards to form huge arms, and by the time the net drags on the bed of the river fishs, which happen to be inside the area are encircled and caught. As the holes of this net are relatively wide, the catch would be of a considerable size. Fishing by the HARBA is only operated by daylight and may be repeated four times a day during the season appropriate to this kind of fish. This is usually in summer, especially during the flood of the Nile.

b) Fishing with the ṬAKIN also needs one boat but a crew of two men and a boy. The net is let in the water as the boat proceeds. One of the crew will beat on the edge of the boat while the latter goes on, and the fishes, terrified by the echo in the water would run ahead into the triple net. They may pass through the wide holes of the outer nets, but will entangle themselves in the smaller holes of the middle net, and remain helpless between the lines. This method of fishing is executed only after sunset and preferably through moonless nights.

c) Fishing with the HABLA needs two boats each with a crew of two men and a boy. The two boats —starting near each other —will row away from each other letting the net in the water between them. Then they turn again to meet and in doing so they keep terrifying the fish by continuous beating on the edges of the boats. As the net is narrow-holed it catches nearly all kinds of fish and all sizes. This explains why the net is called HABLA which means the idiot (which does not distinguish between the size and the kind of fish it catches).

Fishing grounds : The fishermen of Kafr Mishla have two fishing grounds, namely the Nile on the one hand and the main canals on the other hand.

On the Nile fishing rights extend from Kafr Ezzayat in the North to Tunub in the South. This, however, does not mean that no other, fishermen or boats are allowed to practice fishing in this area except those of Kafr Mishla, but rather means that the boats of Kafr Mishla

very rarely exceed these points. Fishing on the Nile is practically all year round, and until few years ago it provided the fishermen with their biggest source. The building of the Idfina dam near the confluence of the Rosetta branch with the Mediterranean Sea is responsible for the diminishing fortune of the fishermen. It is explained by the fact that during the flood the strong current carries with it many fishes across the gates of the dam and let them die because many cannot live in salt water and at the same time cannot return to the sweet water; the structure of the dam hinder their return. Of the main canals nearby there are two : the Baguria irrigation canal to the East of Kafr Mishla, and the Beḥera main canal to the West of the Nile. On the Baguria fishing grounds extend from Qasr Nasr Eddīn in the North to Akua in the South, while on the Beḥera canal it extends from a point a little South of Kafr Salamon in the North to a point opposite Kafr Bolen in the South. The season appropriate to fishing here is only limited to from 20 to 30 days in winter. This is being conditioned by the period already refered to as « Sidda Eshetuia» (clearing the beds of the irrigation canals from mud to avoid silting). For example when the operations is executed to the North of Qasr Nasr Eddīn, the volume of the water southwards is controlled and low, and conditions are favourable for fishing. The fishermen use all kinds of nets except the HARBA. Though the duration of the period is so short, it became the major source of the fishing folk of Kafr Mishla, and at the same time it proves how unrewarded are the efforts of these people.

It is interesting to note that the period of fishing from the Baguria and Beḥera canals is accompanied by a sort of semi-trancehumance. The boats are transported to the canals from Kafr Mishla on animal-drawn carts, while only men and boys who fish take their provisions with them. Because the two canals are not far from their village (the Baguria is 4 kilometers to the East of Kafr Mishla in a direct line, while the Behera canal is some 6 kilometers to the West of the village) the fishermen do not exagerate is their provisions; any body of their families —probably their wives or daughters —can always bring them some more provisions from the village.

This trancehumance needs a great deal of preparations and organization and it is here that we find the topic of this fishing community very

important from the cultural and social point of view. They need to know which of these two canals abound with a good catch. They need to be informed about the time on which the water will be obstructed from running into the canals, for though it is always done in winter when the Nile is low, yet the very date of clearing each part of the canal cannot be fixed absolutely every year, and to know the right date for departure with the wagons and equipment need contacts with the administration. They need to delimit the property rights of each fisherman on the canal to avoid interference of other boats. They need one who meddle among them to settle their disputes concerning fishing rights or else, especially when such disputes surpass the individual basis and attain family level. They need to settle all these matters and a dozen other odds. To answer all these needs the fishermen of Kafr Mishla have a chief—a kind of a 'wise man', a SHIEKH. He is not elected, nor is he (at least at present) a member of the Malayga or the Khalayfa families. The present SHIEKH belong to the Madkur family, and is a respectable personality in the village.

Fishing income : The daily net gains of one boat fishing on the Nile was calculated as 20 piasters, while that of a boat on the canals reaches about 30 piasters. If we assume that a boat will work 150 days on the Nile plus about 30 days in the canals, the total net income of the boat per year will reach the round figure of 40 Egyptian Pounds. Thus the total income of the Fishing community of Kafr Mishla will not exceed 600 Egyptian Pounds yearly. If we divide it by 80 (being the round figure for the whole community) the individual income will be around 7.5 Egyptian Pounds. We will not be far from the truth if we assume that the individual income from fishing in Kafr Mishla vary between 7 and 10 Egyptian Pounds yearly. We must not forget that this income is, in a way or the other, supplemented by some gains from the little land they cultivate.

B) *Handicrafts and other Occupations.*

In the complex of Mishla all handicraft occupations are limited to the direct needs of the rural population. That, however, does not mean

that the area is self-sufficient in every thing. On the contrary, most of the necessities and all luxuries are bought from the urban centers near the complex, e. g., Kafr Ezzayat, and Tanta. By direct needs we mean the fabrication of nearly all the necessities of rural specialities, e. g., carpentary and iron forgery connected with agricultural impliments, or house-building, weaving of woolen blankets, and dress-making.

1. *Weaving :* Weaving appears to be an old-established occupation in Mishla and there are as much as-11 wooden looms engaged in it. There are at least 50 persons who live totaly upon the earnings of these looms, for there are ten families who run the looms individually. Like fishing in Kafr Mishla, there is one family in Mishla who seems to be the oldest among the weavers in this occupation, and it was related to me that many weavers at present have learned the occupation by working first on the three looms which are owned by two brothers of this family at present. All these looms produce a kind of blankets very special to the peasants of the Delta at large; this being made of sheep wool, and much used as covers in winter, or placed over the wooden sofas or over the «mastabas» (benches made of mud-bricks, attached to the exterior wall of the house) instead of mattresses. The coloures of these blankets are usually natural, brown, black and white in strips, but some are dyed according to the wish of the buyers. No designs other than strips are made in Mishla for it is the specialities of the looms of El-Batanun, Fouwa, and Yahudia to make more elaborate designs. Wool is bought by the weavers from the beduins of Awlad ʿAly or Gawabis in Beḥera province, or from markets, especially from the market of Gaʿfaria in the Central Delta. Fleece is bought wholsale from the beduins at a mean price of 15 piasters for each sheep. The wool is then spinned by the peasants at home at a moderate wage paid by the weaver. But in the case of wool bought from markets it is usually already spinned. Customers sometimes provide the weavers with the necessary fleece. A blanket which weighs 20 pounds costs 300 piasters of which the sum of 50 piasters constitute the real wage for the weaver, while 250 piasters represent the cost of the wool. Dyed wool is a bit expensive than natural wool. It was also observed that there are seasons in which the weavers

has much orders while there are seasons of nearly no work. This depends upon the agricultural season, for when there are much work in the field very few peasants are free to spinn the wool. The season also depends upon the season of cash crops, especially wheat, potatoes or cotton, when the peasants have more money to spend, In this season as much as 10 blankets are produced by one loom in the month, while the weaver will be lucky to produce one or two blankets in the month in other times. However the season does not exceed two monthes in the whole year, which coincide with the cotton harvest. In this way we can see that the mean annual income of the weaver varies between 15 and 20 Egyptian Pounds.

2. *Carpenters :* In Mishla there are four persons who provide the population with their needs plus one carpenter in Kafr Mishla. These carpenters are related to each other; two brothers and their cousins who all reside in Mishla. They have only two workshops which are to be found in the courtyard of their houses. The two brothers are married and live together in one house, so do their cousins. The tools they use are the elementary ones, and no electric or mechanical machines are used in the workshop. The production is directed towards agricultural impliments, such as water screw, plough, hoes, etc... Together with making doors, gates, and window shutters. Another field of production is that what concern some house utinsils, like the short-legged round tables, beacking impliments, wooden boxes, ladders, etc. The mean yearly income of a carpenter may not exceed 25 to 3o Pounds. This is a bit higher than gains of other occupations, but one should put into consideration that these carpenters monopolize the whole complex.

3. *Blacksmith :* There is only one blacksmith in the whole complex, and he does not come originally from the area, but has family relations in the near by village of Akua. This blacksmith migrate in a very primitive kind of tent—which is more or less a screen against sun or wind—between Mishla and Kafr Mishla with his wife and children according to the season, but considering the small area of the complex he can always be reached in cases of necessity. However, this blacksmith limit his activities to

making blades, knives, and nails, and mends or repairs hoes, plough-shares, etc. His yearly income may not exceed some 5 to 7 Pounds, and he lives apparently in a very low standered because he, and who belong to his craft, cannot compete with the production of specialized workshops in the urban centers.

4. *Tailors :* In Mishla there are six dress-making shops and seven sewing machines. Two of these shops and simultaneously three machines are owned by one family which represent the oldest tailors in the area and which taught the occupation to all other tailors. All the tailors do not cultivate because they have no land property, and their mean yearly income may reach some 15 Pounds. There are also some five women who practice dress making for the women of the area and their income may be a little less than that of the tailors.

5. *Social services :* This consist of grocers, butchers, barbers, the bakery, the drummers and singers, the undertaker, and all others who provide the villagers with their daily necessities. It has been found that most of those engaged in these occupations do not depend wholly upon its income, but take other jobs beside it. For example many of the owners of the 25 groceries in Mishla own land, or work as contractors for the different Tarahil, or agents for trade or manufacturing companies. This can be also applied to the butchers who own shops. Beside these there are other individuals who have neither land nor any special occupation, but who practice any extra job to win their living.

CONCLUSION

One can see from this survey that there are two kinds of problems the roots of which arise from the same causes prevalent not only in the Mishla complex, but all over the greater part of the Delta. There are local problems which had to be solved and cannot be solved without the intimate interest and study which a local government can achieve. For example one should seriously think of legalising the status of the agricultural worker in what concern the daily houres, fixing the wages

according to the season and kind of work, compensations in cases of any harm during the work, etc. One can venture to say that a proper solution of such problems is many sided and must not be confined to the locality, but has to reach a level where many local governments should cooperate among themselves. It is here that we may detect the other kind of problems, namely the inter-regional problem. Poverty could be picked up as one of the main causes of the prevailing problems, and similarly over-population can be blamed. But this will not change the fact that land-hunger lies at the very roots of our agrarian problems. Land-hunger is enhanced by the fact that at present more mechanisation is applied in Egyptian agriculture, which means more unemployment. Organising the tarahil workers on legal basis, or seeking a local solution to the problem of the fishing community or the rural handicrafts can succeed only if it was supported by the following items :

1. the rehabilitation of as much as possible of families in the less populated areas in Northern Delta, including most of Beḥera province to help land reclamation ;

2. establishing a teaching method for developing and propagating rural industries (e. g. by quoting the designs of El-Batanun in weaving, and providing the weavers with modern looms) ;

3. establishing more occupational schools to teach the workers of the industrial tarahil, among others, how to be skilled labourers. These schools must be attached to the industrial areas to which the workers seasonally flow, as for example Kafr Ezzayat or Kafr Eddauar.

NORTH-EAST IRAQ : A PHYSIOGRAPHICAL STUDY[1]

BY

Y. ABUL HAGGAG

GENERAL CHARACTERISTICS

The north-eastern part of Iraq lying between the Iranian and Turkish frontiers on the one hand and a line extending from Jabal Sinjar in the north-west to the Mandali area south of Khanaqin in the south-east on the other (Fig. 1) is possessed of an impressive general unity in several respects. Structurally, the Sinjar-Mandali line marks a strikingly distinct boundary, separating as it does the unfolded Iraq to the west and south from the folded zone to the north and east. It is true that the « unfolded » part is not devoid of folding, especially in its eastern section which is structurally part of the « Unstable Platform ». The folds here are, however, few in number and of very small dimensions, while most of them bear no directional relationship to the trends of the folded zone [2]. The astonishingly large number of folds in the Dulaim and Jezira provinces as shown in Mitchell's map published in a previous issue of the Bulletin [3] are in fact no more than feeble wrinkles of very low dips and dubious or no closures.

The Sinjar-Mandali line, on the other hand, coincides with the southernmost and westernmost anticlines of the folded North-east Iraq. Jabals Sinjar, Sheikh Ibrahim, Makhul and Hamrin which mark this line are welldefined folds, rising in most places more than 200 metres above

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(1) Based partly on observations made during a short sejourn by the author in Iraqi Kurdistan in February 1959 and a short visit to the southern part of Jabal Hamrin in the same year.

(2) Dunnington, 5, p. 1197.

(3) Mitchell, 13, p. 88 (map).

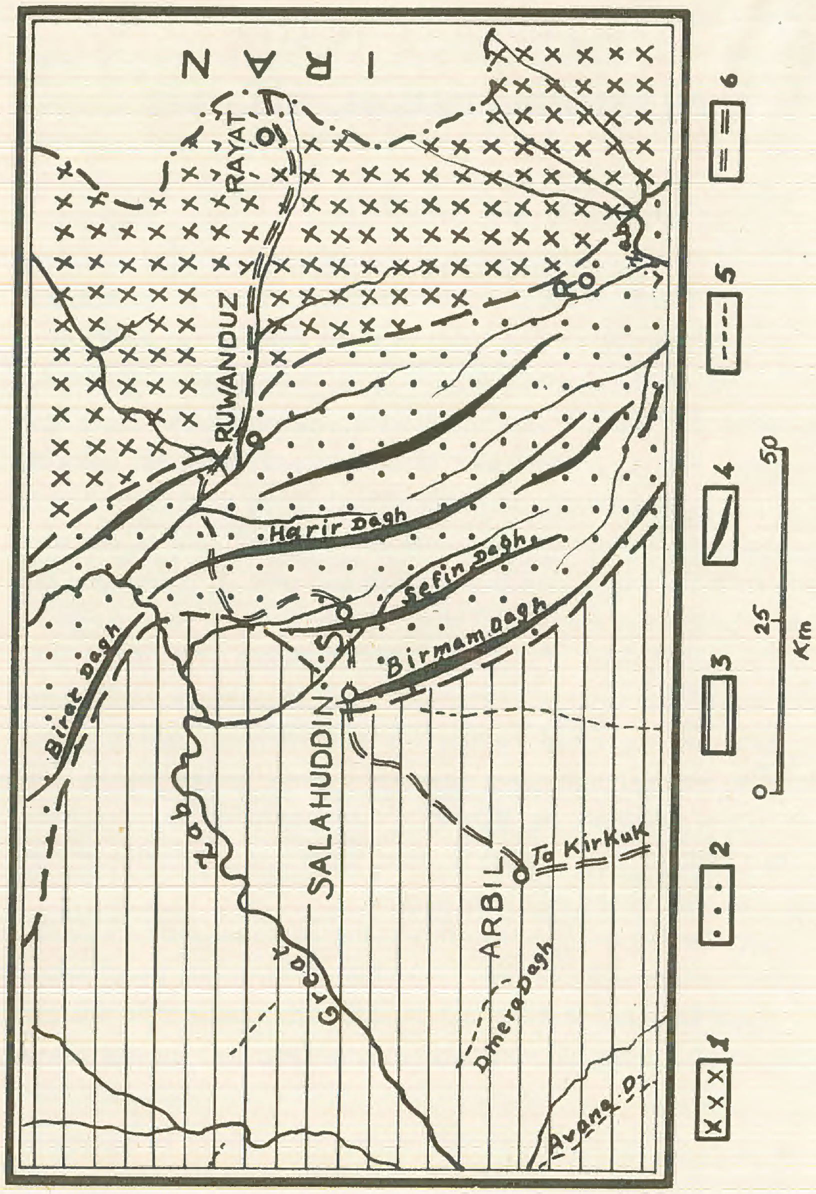

Fig. 1. A representative portion of North-east Iraq.
1 — «Nappe» zone; 2 — Mountainous folded zone; 3 — Piedmont plains; 4 — Anticlinal ridges; 5 — Minor anticlines; 6 — Road; S = Shaqlawa; R = Rania.

the adjacent synclinal plains (Fig. 2). It is no coincidence that the south-western administrative boundary of both the Mosul and the Kirkuk provinces (liwas) are so closely associated with this arcuate structural line. Even the rather sudden change of trend made by the administrative boundary west of the Qayara zone south of Mosul is to a great extent structurally determined, the structural boundary assuming here the north-south alignment of the pitching extremities of a number of small anticlines that exist in this zone.

There can be no doubt that the structural make-up of North-east Iraq has played the most important role in moulding its geographical landscape.

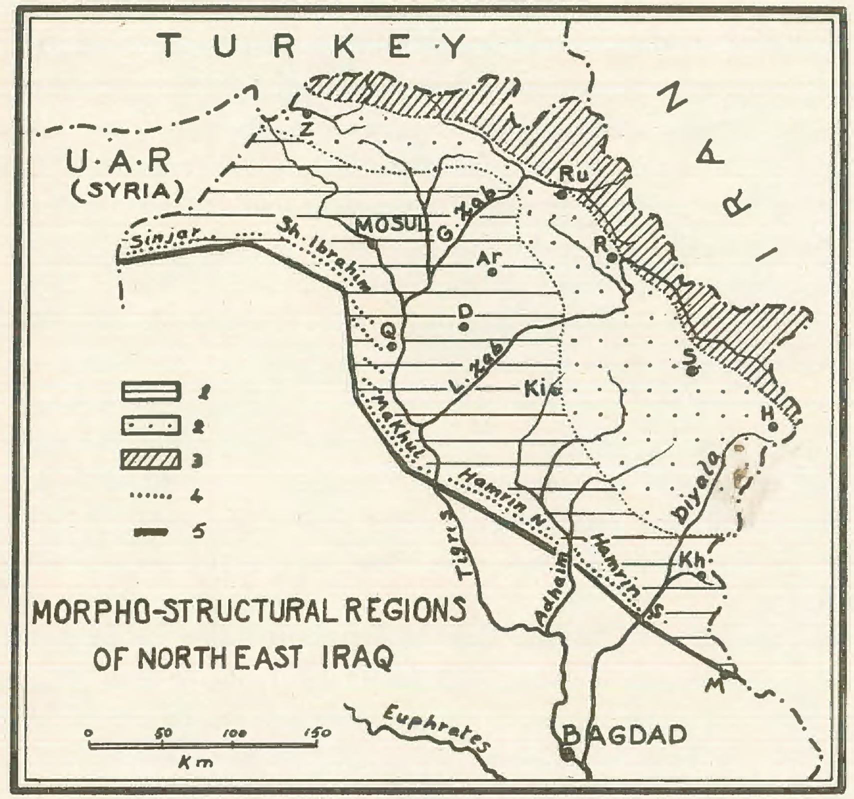

Fig. 2. Morpho-Structural regions of North-east Iraq.

1 — Piedmont plains; 2 — Mountainous folded zone; 3 — «Nappe» zone; 4 — Main bordering anticlines; 5 — Boundary line; Ar. = Arbil; D. = Dibega; H. = Halabja; Kh. = Khanaqin; Ki. = Kirkuk; Q. = Qayara; R. = Rania; Ru. = Ruwanduz; S. = Sulaimaniya; Z. = Zakho.

The frequent recurrence of distinctive morphological phenomena related directly to the folded structure of the region is indicative of a general unity of geomorphic developement quite distinct from that of the rest of Iraq. Taken together, structure and morphology provide, as we shall attempt to show, the best basis for a division of North-east Iraq into geographical sub-regions.

Its relatively high altitude, itself an outcome of the Tertiary orogeny, and its location in the path of the winter and spring east-moving Mediterranean depressions endowed the region with the highest rainfall in Iraq, the annual totals ranging from 300 mm. in the south to more than 1000 mm. in the north. The percentage of spring rainfall to winter rainfall is higher than in Central and Southern Iraq, spring depressions being much more restricted to a northerly track than those of winter. Another climatic feature is the pronounced continentality due to the inland position and lack of wide water bodies. Continentality is of course a characteristic of the climate of the whole Iraq, but in the lowlands of the region it is somewhat more pronounced than in the extreme south (compare the annual range of Mosul, 16.5° C. to that of Basra, 13.7° C.). Winter is colder and in the higher north-facing mountain-slopes where snow persists for several weeks even at an elevation as low as 600 metres above sea-level. It was rather an unexpected scene for our party that in February, the water-drops falling from the rocky ledges by the road cut along the Geli Ali gorge, between Shaqlawa and Ruwanduz, freezed instantaneously into beautiful long icicles (Plate I); while in the Shaqlawa plain water froze in the jugs in the early morning.

An appraisal of the climatic individuality of the region can be gained from a consideration of the limit of rainfall cultivation in Iraq. Fixing the best isohyet that represents the boundary between the dry farming zone and the irrigation zone in Iraq is not, however, an easy matter. Barley can be grown on less than 200 mm. But a vital factor in the delimitation is the great variability in annual precipitation. Taking this factor into consideration, by plotting reliability of precipitation against the average mean totals for four years, Davies draws the southward limit of the rainfall zone as a more or less arcuate line extending roughly

from the neighbourhood of Khanaqin to Kirkuk and Qayara, then trending almost due west to the Iraqi-Syrian frontiers [1]. This line, we may note, is quite close to the 350 mm. isohyet which runs a little south of Mosul (418 mm.) and of Kirkuk (401 mm.) and north of Khanaqin (323 mm.) (Fig. 3), and which, incidentally is the isohyet

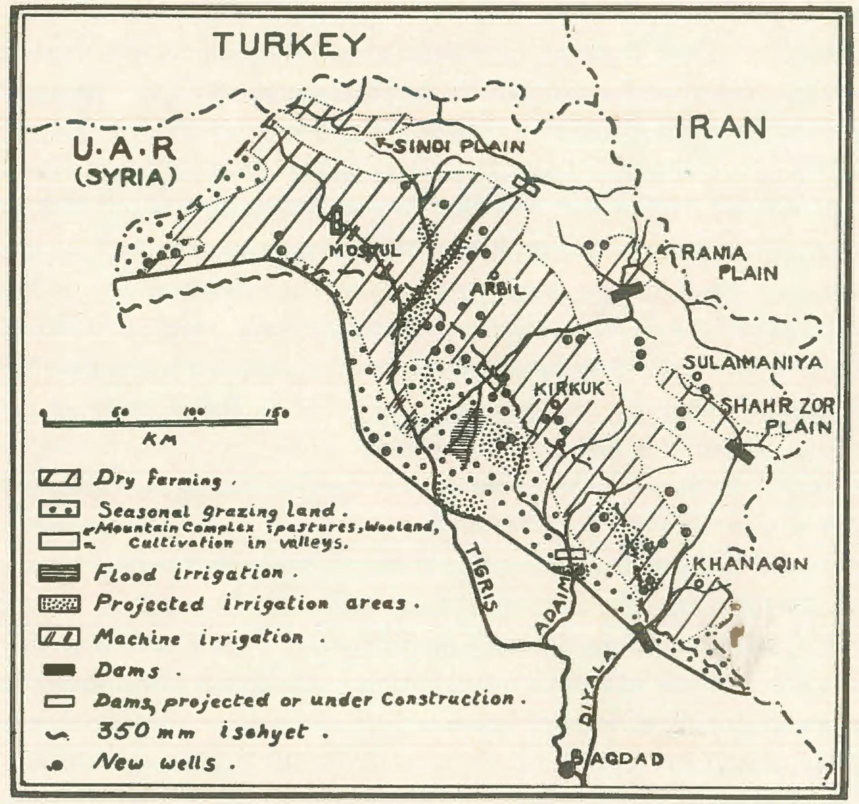

Fig. 3. Land utilisation in North-east Iraq.

adopted by North African geographers for the same purpose [2]. When it is noted also that this 350 mm. isohyet correlates well with the southward limit of permanent rural settlement dependent upon rainfall

[1] Davies, 4, p. 128 (map).
[2] Birot et Dresch, I, p. 435.

cultivation, it can be concluded that, with the exception of the relatively small marginal area extending immediately east of the Hamrin and Makhul hills, North-east Iraq is climatically suited to permanent rainfall cultivation. In no other part of Iraq is this type of cultivation possible, small amount and great variability of precipitations in the limited areas lying beyond the Sinjar-Mandali line allowing only sporadic cultivation and semi-nomadic herding.

North-east Iraq is hence essentially a region of winter rain-watered cereals, particularly wheat and barley, producing also Mediterranean fruits. Its four administrative provinces, namely the Mosul, Kirkuk, Sulaimaniya and Arbil liwas [1], produce about 90 % of Iraq's wheat and 36 % of its barlay [2]. Of the trees of fruit-bearing age, the four provinces contribute almost all the almonds and walnuts, 60 % of the pears, 32 % of the peaches, 17 % of the pomegranates and smaller percentages of apricots and apples. North-east Iraq grows all the Iraqi tobacco. It is also a main contributor to the country's animal wealth, containing about 75 % of its goats, 35 % of the sheep, 30 % of the cattle and, naturally enough, almost all its mules.

Above all, the region contains most of Iraq's oilfields, including the Kirkuk giant and the fields of Butma, Ain Zala, Qayara and the newly confirmed fields of Jambur and Bai Hassan. Nearly 200 million barrels are produced annually from this folded land of the Kurds [3].

The Kurds constitute the majority of the population, and it is they who give this part of Iraq its distinct ethnographical and social character. A mountain-folk, they tend, however, to give place to the Arabs in the plain-lands of the region, mainly the plains of the Mosul liwa where the the Arabs are in the majority, and those of the Kirkuk liwa where Arabs and Turkomans constitute a high percentage of the population. The

[1] North-east Iraq, as defined in this paper, consists of these four liwas and a relatively very small portion, in the extreme south-east, which is part of the Diyala liwa.

[2] Percentages in the paragraph are calculated mainly from the 1952-1953 Agricultural Census.

[3] Dunington, 5, p. 1195.

Kurds, in fact, constitute the great majority only in the provinces of Sulaimaniya (almost 100 %) and Arbil (91 %), while the percentage falls to 52.5 % in the Kirkuk liwa and to only 35 % in the Mosul liwa [1].

ALONG THE KIRKUK-RUWANDUZ ROAD

Inspite of its general individuality North-east Iraq, when studied in some detail, displays a number of more or less differing geographical landscapes. A main purpose of this paper is to throw some light on this « unity within diversity », and to bring out the dominant role played by structure and morphology in this respect. The road from Kirkuk to the Iranian frontiers by way of Arbil and Ruwanduz offers an ideal geographical cross-section of the region (Fig. 1). It may therefore be useful to begin our regional analysis with a brief exposition of the observations made along that road.

Fom Kirkuk to Arbil the general impression conveyed to the eye of the traveller is that of a vast undulating plain, even though hills or ridges are always in sight. The water-courses, mainly tributaries of the Little Zab, have a limited erosive power, their valleys being shallow and sometimes hardly perciptible. The main river itself, the Little Zab, is not deeply incised, as can be observed at altun Kupri where it is crossed by the road. Morphologically, one is always reminded of the piedmont character of the landscape. That it is also a steppeland, part of the transitional zone between the mountains and the arid zone, is abundantly confirmed by the scene of the ploughs drawn by mules or donkeys and manned by Kurds in a country without canals or irrigation machines; by the shepherds, also Kurds, tending their sheep and goats, as well as by the complete lack of trees.

The transitional piedmont character is also noticeable in the two famous towns lying at the ends of this section of the road, namely Kirkuk (120, 593 inhabitants [2]) and Arbil (34, 751 [2]). In both towns the heterogeneity of the population is easily discernible, with Kurds,

[1] Edmunds, 6, p. 52.

[2] General Census of 1957, 9, pp. 7 and 8.

Turcomans and Arabs co-existing. With the many manifestations of its oil industry and the stronger relief of its surroundings Kirkuk is the more colourful, but both are essentially ancient piedmont urban centres and, in both, the characteristic mound of ruined ancient settlements is to be seen. (Plate II).

East of Arbil the road runs first through a country that is almost identical with the Kirkuk-Arbil tract in all essentials of the landscape. Soon one begins to enter the mountainous zone. The foothills first, almost bare of trees, with a semi-arid aspect even in February, rather forbidding and repulsive. Yet it is not a really rugged country, and the hills are every-where round-summitted and smoothly contoured. This seems to be partly associated with the lithologic constitution of the rocks, mainly shale, gypsum, sandstone and conglomarate of the Neogene series. In limestone areas the relief is much less subdued.

A short distance further east one is in plain mountainland, heralded by the impressive Birman Dagh, first of the Kurdistan mountains proper. This is a conspicuous anticline of rocky and abrupt slopes, consisting mainly of limestone. On its summit, at a road distance of 32 kilometres from Arbil, lies the summer resort of Salahuddin. Save this small town no important settlements are encountered, and only Kurdish shepherds are seen here and there pasturing their sheep and goats amongst the rocky slopes.

With Birmam Dagh the traveller is introduced to one of the most striking morphological features of Kurdistan, namely the succession of parallel anticlinal ridges and synclinal valleys. Thus from this mountain the road descends to a strike valley east of which rises the Sefin Dagh, another anticlinal mountain consisting of Eocene limestone. The road then descends to another synclinal structure, namely the Shaqlawa basin which is occupied by the strike valley of a small left tributary of the Creat Zab (Plate VI).

Arriving at a synclinal valley the traveller is struck not only by the obvious structural and topographical change, but also by the sudden change in land use and settlement. Thus the rather dreary aspect of the Sefin Dagh anticline with its slopes almost devoid of trees and its summits powdered with snow, gives place to the fields and villages of

the Shaqlawa basin. Here, at a road distance of 51 kilometres from Arbil, lies Shaqlawa, a picturesque small town (4254 inhabitants), whose trees afford a welcome note of green contrasting with the grey and white mountains towering on either hand.

The frequent scene of the mules and donkeys carrying tree branches and shrubs brought from the neighbouring hills to be used as firewood, is a reminder of one of the chief ways in which the mountains of Kurdistan have been deprived of their vegetative cover (Plate III). Yet the scene of the same animals drawing the ploughs in this intermontane fertile basin, and that of the sturdy inhabitants facing a severe cold and tilling a land that must have been settled since thousands of years, afford not only an explanation but also much excuse for what has been rather unjustly described as the «ruthless» extermination of vegetation in this country.

Between the Saqlawa basin and the Ruwanduz mountains the traveller crosses one of the most scenic parts of Iraqi Kurdistan. The feature of anticlinal ridges and synclinal valleys persists, but the scenery becomes much bolder and more striking, comprising lofty mountains, bare cliffs and, above all, the Geli Ali Bey gorge.

After descending the anticlinal Harir Dagh, and at a road distance of 49 kilometres from Shaqlawa, the road enters this magnificent gorge that has been formed by the Alan Sou, an affluent of the Ruwanduz which is a left tributary to the Great Zab. Bordered by huge walls of limestone with quite 1000 feet sheer precipice, it is a veritable canyon of striking grandeur. Looking down at the valley bottom from the splendid road that has been skilfully cut out of the rocky wall one is stuck by the scene of the huge boulders that had fallen from the sides and one may be tempted to look for the carcasses of the unfortunate animals that are said to fall occasionally down from the summit of the gorge walls 300 metres above.

The gorge continues along the Ruwanduz stream also, but just before the two streams meet another magnificent feature is to be seen, namely the water-fall made by the Alan Sou. The water drops here from a height of some 20 metres, although the width of the waterfall does not exceed two metres.

For a moment the observer may wonder at the lack of proportion between this huge gorge and the small, seemingly weak stream running on the bottom and, if he is not geomorphologically minded, he may even be tempted to discard the possibility of a fluvial origin altogether. The tortuous course taken by the gorge and the knowledge that rivers can achieve even greater deeds will of course soon dissipate such doubts.

Between this unforgettable gorge and the town of Ruwanduz the road runs mainly through Cretaceous formations of varying lithologic constitution including limestones, marls and shales. Although the folds continue to be of the simple type and the hills remain generally round-summited and devoid of jagged outlines, relief becomes increasingly strong, and gully erosin, especially in the shale terrain is well developed. Fallen rock-fragments are rather widespread on the plains in places. Sometimes they are used for building rough low walls for separation of fields, while mounds of them may be seen in these fields, having been piled away by the Kurdish farmers in their effort to render the soil more tillable. The biological, including the human, landscape does not, however, display any radical change from that prevailing in the mountainous zone as a whole. The scarcity of trees, the mules and donkeys drawing ploughs (aided sometimes by cows) or carrying firewood, the shepherds looking after their sheep and goats, the occasional scene of the nomads' tents, the villages perched on some favourable terrace-all these are reccuring scenes throughout the zone (Plates VIII, X).

Ruwanduz, 130 kilometres road distance from Arbil, is a picturesque small town (8144 inhabitants)[1], some 800 metres above sea-level. With its neighbouring high, snow-capped mountain, its location on a plateau bounded by forbidding precipices and its deeply incised and inaccessible river, this town has become one of the most important strategic centres of Iraqi Kurdistan.

Ruwanduz lies in the contact zone between the gently folded area through which the road has been running (from Birman Dagh to Ruwanduz) and the generally higher belt of complicated folds and complicated morphology across which it continues to the Iranian frontiers near Rayat.

[1] General Census of 1957, 9, p. 7.

MORPHO-STRUCTURAL SUBREGIONS

With this traverse in mind, we may now proceed to a consideration of the subregions into which North-east Iraq can be divided. Three subregions can be distinguished. (Figs. 1 and 2). The piedmont plains, well exemplified in our traverse between Kirkuk and the foothills below the Birman Dagh anticline, constitutes a distinct zone. In any general view, the whole remaining part of North-east Iraq can be taken as another distinct unit, the mountainous zone. But in any detailed study, and by giving the structure and morphology the weight they deserve, this zone should be subdivided into a generally lower province of simpler folds, exemplified in the traverse by the Birmam Dagh-Ruwanduz tract, and a higher province of complicated folds, the «nappe» zone, exemplified by the Ruwanduz—Rayat tract.

The boundaries between these divisions are shown in Fig. 2. They are based on both structural and morphological criteria. The divisions they delimit are to be regarded as more or less distinct morpho-structural provinces, but with the very marked effects of structure and morphology on the other contents of the geographical landscape, they may well be taken as the geographical subregions of North-east Iraq.

The boundary between the two mountainous zones (2 and 3 in Fig. 2) calls for no comment. We have adopted here the line suggested by Husted[1], which, from north of Zakho in the north-west to the neighbourhood of Halabja in the south-east, generally follows the longitudinal valleys of the Khabour, the Upper Great Zab and the Upper Little Zab (Fig. 2). From the structural and morphological standpoints it represents a fairly well defined boundary.

The boundary suggested by Husted to delimit the piedmont plains (his Sub-Montane Zone) and the adjacent mountainous zone has however, been partly modified. In its northern part it extends along the foot of the large anticlinal massifs rising abruptly above the plains, from Jabal el-Abiad south of Zakho to the Birman Dagh north of the Little

[1] Husted, 8, p. 18.

Zab. Our boundary does not, however, continue southeastwards along the ranges lying in the extension of the Birman Dagh axis, but swing southwestwards and then southeastwards to include into the mountainous zone the country extending immediately south-east of Kirkuk. Structurally this country is in fact transitional between the simply folded mountainous zone and the piedmont plains where folds ere of less amplitude. Morphologically, however, it is a hilly, badly dissected country (Plate X), with anticlinal ridges that can attain an elevation of 1000 metres or more above sea-level and synclinal valleys at 400-600 metres above sea-level. Such a hilly country with such a strong relief is better placed in the mountainous zone. The piedmont plains, to a consideration of which we may now proceed, offer quite a different picture.

I. THE PIEDMONT PLAINS

The morphological landscape of this zone is one of a great simplicity. From the Sinjar zone in the north-west to the Khanaqin area in the south-east, the general picture is that of rolling plains of synclinal structure, diversified by anticlinal hills which are, however, of a relatively very restricted areal extent. A sheet of Pleistocene alluvium covers the surface in most places, being underlain by the Pliocene deltaic series of conglomerates and coarse sandstones (the so-called Bakhtiari series) as in the Arbil plain, or by Miocene formations ranging from the Upper Fars clastics of the Kirkuk plain to the lower and Middle Fare limestone conglomerate, gypsum and shale of the western Assyrian plain. These underlying formations ouctrop in places, as in the last mentioned zone which is therefore of limited fertility.

The plains are only little dissected. Although somewhat deeply incised in places, the water-courses generally have shallow valleys. In places they meander freely across wide flood plains, as is especially the case in the southern tracts traversed by the Little Zab and the Diyala.

The hills are characteristically simple upfolds. Few of them have also experienced faulting. The Kirkuk oil-field, for instance, is a sinuous anticline that is overthrust from the north-east in the exposed beds, although at a medium depth it is simple and quite symmetrical.

With few exceptions, however, we are dealing with low hills that owe their prominence in the visible landscape to their isolation rather than to their height. The southern « Jabal» Hamrin, so conspicuous a feature to the observer arriving from the Mesopotamian flood-plain, is only some 150 metres above the surronding plain. Seen from the Kirkuk-Arbil road the Avana Dagh is a prominent feature, but it rises only little more than 200 metres above the general level; while the Dmeira Dagh near Arbil is also of a similar height. (Fig. 1). It is further to be noted that the general tendency for anticlines to diminish in amplitude with increasing distance from the « nappe» zone does not hold good in the piedmont plains. The Sinjar, Makhul and Hamrin North hills are much larger and higher upfolds than the anticlines which occur immediately to the north and the north-east. Anoother anomaly is the difference of altitude that exists sometimes between neighbouring anticlines of otherwise similar dimensions. Thus the parallel Avana Dagh and Karachok Dagh anticlines of the Dibega zone attain respectively 550 metres and 900 metres above sea-level, although they are only some 10 miles apart. These and other anomalies which occur also in the adjacent mountainous zone, may be explained in the light of the view, held by some geologists that the late Tertiary folding was super imposed on a preexisting complex of faults inherited from pre-Miocene times. Residual features left from this faulted surface may thus have interfered with the regularity of the Pliocene folding.

The hills of the piedmont plains have undergone much erosion since their appearance in the late Tertiary. In most cases the capping strata have been removed from the crests to expose Oligocene limestone, as e.g. in Karacholk Dagh and Jabal Malub, Eocene or even Cretaceous limestone as in J. Sinjar. An idea of the dissection suffered for instance by Jabal Hamrin may be gained from Plate XII where erosion is seen to have cut through the anticlinal crest, subsequent strike valleys and inward-facing scarps being well developed features.

A remarkable feature which calls for explanation is the presence of transverse reaches carved out by the consequent streams of the subregion across the anticlinal ridges. The Diyala cuts across the Hamrin ridge with a gorge instead of following the easier route around its southern

extremity, where the folded beds disappear below an alluvium cover spread on a flat country. The Adhaim cutting also across the Hamrin anticline, the Great Zab across the Qayara anticline and the Tigris across the Makhul anticline are other examples of the feature.

The origin of this peculiarity has not been adequately explained. The current view is that these transverse reaches are antecedent to the folding of the piedmont zone which dates from the late Pliocene, as evidenced by the uppermost strata involved in this movement, namely the Bakhtiari conglomerates and coarse sandstones which had been washed down from the mountains to the east and then folded. Since folding was gentle the vigorous consequent streams flowing down from the high mountains of Kurdistan could maintain their former courses against the rising folds. The transverse reaches of the piedmont plains are thus held to be similar in origin to the transverse courses of the Sutlej and other rivers in the similarly situated marginal zone of the Himalayas.

However, a superimposed origin cannot, we think, be lightly dismissed. Geological evidence indicates that the Pliocene folding movement which was commencing already in the lower Pliocene went on intermittently throughout the duration of the deposition of the Bakhiari series. In later stages of this deposition « coarse sediments were being laid down thinly *over the rising crests* of the southwestern folds, and more thickly in the deepening synclines» [1]. In other words the rising of the anticlinal structures took place *pari passu* with intense deposition. That even the crests were covered indicates that the landscape of the piedmont zone must have been at that time of a very faint relief. The streams flowed then on an almost flat surface of coarse sediments as normal extended consequents, with the underlying folds very near to the surface. With subsequent (early Pleistocene?) erosion removing the thin covering layers from the crests and resurrecting the whole underlying folded structure the streams retained their former courses determined by the original slope of the cover, and could thus cut across the anticlinal ridges as superimposed transverse reaches. This, however, is only a tentative

[1] Dunnington, 5, p. 1219. The italics are by the present writer.

explanation for which we do not clain any morphological evidence at present.

Human conditions :

In the piedmont plains both the synclines and the anticlines have their distinct contribution in moulding the anthropo-geographical landscape. The synclinal plains with their slightly inclined strata—and hence a level surface—and generally fertile alluvial soils are settled by a mainly farming population. In these plains of the eastern part of the Fertile Crescent is found one of the relatively greatest densities of rural population in Iraq. Not all parts are so densely populated, however, in contrast to the Assyrian plains in the north, the southernmost plain lying immediately east of the Hamrin and Makhul ridges is almost unsettled, except by nomadic shepherds grazing their sheep and goats in winter and spring and carrying out a sporadic cultivation. This plain lies, in fact, in the « zone of uncertainty» where the annual rainfall is not only less than 350 mm., but is also quite variable (Fig. 3). The fertility of the soil in parts of this plain, will, however, permit permanent cultivation if the projected irrigation schemes are carried out (Fig. 3).

The anticlinal hills, bare and forbidding as they are in most places, contribute two vital liquids, water and oil. Rainwater falling on them percolates into their porous rocks to emerage at their foot in the form of springs which are of great importance to the inhabitants of the synclinal plains, as e.g. those of the Dibega plain which lies between the Avana Dagh and Karachok Dagh anticlines.

Great quantities of oil are housed in the Eocene, Oligocene and Miocene limestones of many of these anticlinal traps. The huge Kirkuk oil-field, a sinuous anticline 100 kilometres long, is the largest in the world, with producible reserves estimated at 100 million tons. All the remaining fields of North-east Iraq, mentioned before, are situated in the piedmont plains.

It may finally be noted that, true to its locational function, this piedmont borderland is a country of important urban centres. Most of these are in fact typical foothill towns genetically comparable to those of the Alpine foot in Italy or the Fall line in the United States. They originated as

market places where the products of the mountainous zone and those of the piedmont zone can be exchanged. Mosul, the largest town of the subregion, is not quite a typical example of foothill towns, and it has benefitted from its location on the Tigris in a rich plain as much as from its commercial relations with the mountainous zone to which it is not in fact very close. But a magnificent series of really typical foothill towns dots the contact zone between the Khanaqin and Arbil areas (Fig. 4). An indication of their antiquity is the frequent presence of

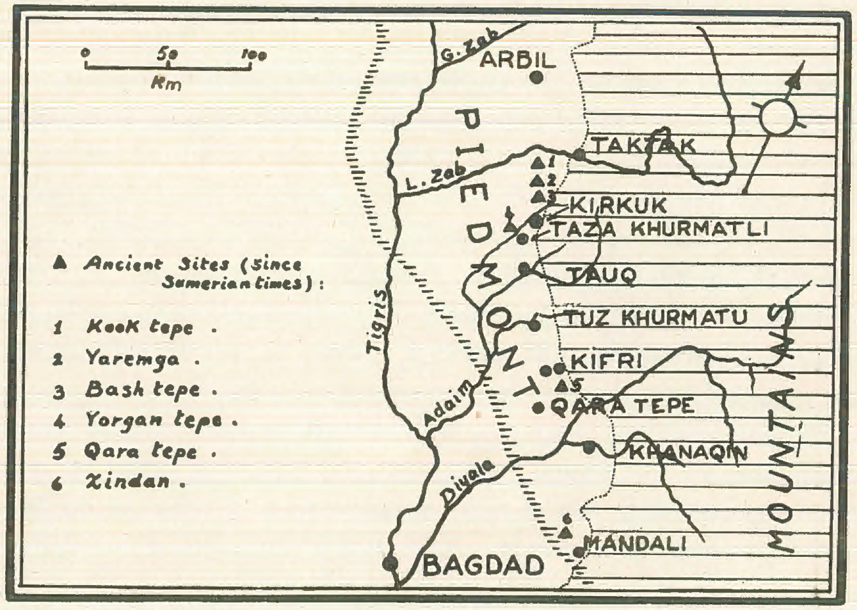

Fig. 4. Foothill towns in North-east Iraq.
(Ancient sites from Department of Antiquities map, 10).

mounds or « tepe » representing remnants of older settlements on which the modern towns are partly built. Kirkuk is built on such a « tepe » in which are buried older settlements going back at least as far as the end of the third millenium B.C.[1], while part of Arbil (the ancient Arbela)[2] lies on a « tepe » rising some 30 metres above the adjacent

[1] Encyclopaedia Britannica, under 'Kirkuk'.
[2] Birot et Dresch, I, p. 325 (map).

plain (Plate II). It should also be noted that a number of ancient centres lying near or between the surviving towns are now indicated by the presence of ruins in their sites (Fig. 4).

II. THE MOUNTAINOUS FOLDED ZONE

In contrast to conditions in the piedmont plains the emphasis in this subregion (2 in fig. 2) is, morphologically, more on the anticlinal mountains than on the synclinal plains which, though remaining of vital impotence from the anthropho-geographical standpoint, are of relatively small areal extent. Elongated broad and open folds are characteristic, and the whole subregion may be likened to the Jura mountains of Switzerland, although it is a Jura without plateaux. The correspondence of relief and structure, in the sense that the ridges are of an anticlinal structure while the synclines form plains, is a remarkable feature with which we shall deal later.

The water-courses have two main alignments constituting a rectangular pattern of drainage. They are either longitudinal consequents running along the synclinal troughs parallel to the trend of the ridges, or transverse streams trending across the regional slope. Extending our view to Iran where most of these streams rise, the former alignment is by far the more dominant. In Iraqi Kurdistan it is well represented by the upper reaches of the two Zabs and by most of their tributaries (Fig. 1, 2). The remaining reaches of both rivers are of the transverse type, each joining the first alignment in a great bend. The Diyala and Adhaim rivers are, however, transverse rivers almost throughout their whole courses.

The longitudinal reaches are generally of low gradients, and aggradation is much more pronounced than erosion. In contrast, the transverse reaches plunge to the piedmont plains in deep, steep-sided valleys narrowing in many place into veritable ravines and imposing gorges that often cut across the anticlinal ridges. In its transverse reach, the Great Zab, for instance, runs into a long series of tortuous gorges from which it never manages to escape even for a brief moment until but a comparatively short distance before its juction with the Tigris[1].

[1] Maunsell, 12, p. 130.

To Blanchard [1] the transverse Diyala valley may have been determined by a transverse warp. Failing geological evidence for this, and taking into consideration that transverse reaches and gorges are represented in all the main rivers, antecedence seems to provide a better explanation. The intermittency of the Pliocene folding and the steepness of the regional slope which bestowed on the consequent reaches a great erosive power are factors that must have greatly helped the streams to maintain their courses across the rising anticlines.

Attention may finally be focused on the problematic matching of relief and structure in the subregion. Complete correspondence is not claimed. In certain parts subsequent features are present. In the Duhok area the crest of the anticline lying north of the town has been largely eroded off and is now bounded by prominent high inward-facing scraps [2]. A similar breaching of the crests by erosion has also been noted in the Amadia zone and in the country extending south-east of Kirkuk.

The fact remains, however, that unbreached anticlines and synclinal valleys are salient features of the landscape in the subregion. This is rather curious since, generally speaking, consequent forms in folded regions are rare occurrences. The anticlines are destined to rapid destruct-ion and the 'survival of one-cycle mountains from the Alpine movement, if it can be substantiated, must be quite exceptional' [3].

Since on stratigraphical grounds a resequent origin cannot, however, be easily invoked, a consequent origin must inevitably be faced. The present anticlinal ridges and synclinal basins are not, of course, to be conceived of as the initial forms of the folding movement. As noted before, a vast thickness of rock, represented by the Bakhtiari series, has been removed from the mountains [4]. The removal of the rocks may however, be visualised to have proceeded in the way shown in Fig. 5, with the consequent landforms (antclinal ridges and synclinal valleys)

[1] Blanchard, 2, p. 130.
[2] Husted, 8, p. 13.
[3] Cotton, 3, p. 119.
[4] According to Mitchell (14, p. 294, table I) the Bakhtiari series attains a thickness of 1480 metres.

losing in altitude but retaining their general structural outlines. The relative recency of the folding movement which reached its climax only in late Pliocene time, the prevalence of broad, gentle folds which are less vulnerable to erosion than closely packed folds and, perhaps, the slow tempo of erosion in this zone of semi-Mediterranean climate are

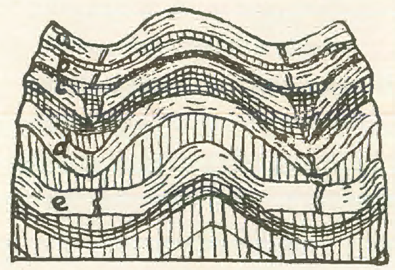

Fig. 5. Diagram illustrating stages (a — e) in a one-cycle development of a simply folded region with survival of consequent features. (From Cotton, 3, p. 124).

facts to be taken into consideration in the rather difficult task of explaining this remarkable matching of morphology and structure.

Human conditions :

As in the piedmont plains, settlement in the mountainous folded zone is concentrated mainly in the synclinal plains, of which the Sindi plain, the Rania plain and the Shahr Zor plain are the largest (Fig. 3). These are the most densely populated parts of the mountainous zone, with cultivation as the main occupation. The major towns of the sub-region are located here, including Sulaimaniya, Halabja, Rania and Zakho.

The anticlinal mountains and the transverse valleys are less favourable for settlement. The former are badly affected by soil-erosion, their surface being now often rocky and bare. Where they consist of limestone, as they often do, much of the rainwater percolates through this porous rock. Hence cultivation, of a patchy character, is generally limited to

their lower slopes, and grazing is the main occupation possible. The transverse valleys are narrow, and in many places their rapid tortuous torrents flow between rocky walls with little room even for rough paths along their banks. It is a striking, but explicable, fact that no urban centres of any size exist on the anticlinal mountains or in the transverse valleys.

In comparision with the piedmont plains the mountainous folded zone is a country of averse physical conditions and meagre potentialities. Available arable land is of a relatively small extent. Springs are fed by variable quantities of rain and snow. Winter rain cultivation and pastures are no less menaced by the vagaries of the climate, while soil erosion is another menace. The surviving forests consist mainly of small oak trees suitable only for firewood and charcoal burning, their use as sawlogs being prevented by their short boles which are also not sufficiently straight [1]. The subregion as a whole is therfore rather sparsely populated. The distribution of settlement is of a patchy character. The towns are small, the largest of thesm, Sulaimaniya, having a populat. ion of only 48.450 souls [2].

The real importance of this subregion to Iraq lies in its strategic situation and in the fact that it embraces, in the transverse reaches of its rivers, ideal sites for constructing irrigation and flood-water dams of which one on the the little Zab and another on the Diyala have already been completed (Fig. 3).

III. THE «NAPPE» ZONE

The country lying north and east of the already mentioned boundary extending from north of Zakho to the neighbourhood of Halabja (Fig. 2) presents many distinctive features. In the first place it has been a land of violent tectonic disturbances, much more violent than in the neighbouring gently folded zone. Under a great compressive force the folds were here made recumbent, then broken and over-thrust. By these violent

(1) Stellingwerf, 16, pp. 2, 6.
(2) General Census of 1957, 9, p. 7.

movements great wedges of the crust were translated from their original positions, piling themselves one on top of the other. To such translated masses the French term «nappe» is usually given, and hence our «nappe zone».

Such a complicated mountain structure is, of course, bound to give rise to a complicated morphological landscape. The presence of igneous and metamorphic rocks together with the sedimentary formations adds to the confusion. Glacial erosion, moreover, is greater here than in the neighbouring subregion, the «nappe» zone mountains attaining higher altitudes ranging from 2000 to 3000 metres above sea-level and hence having a larger share of snow-fiedlds. The rectangular pattern of drainage gives place to irregular valley trends. Relief is strong and the landscape assumes an almost Alpine grandeur.

Human conditions :

As should be expected from this brief general descripiton of structure and morphology, the 'nappe' zone is the least suitable part of North-east Iraq for human activity. To the difficult terrain and severe winter cold is added a remoteness that has kept the sparse, mainly transhumant population at an early stage of economic and cultural development. Deforestation has been carried out on a smaller scale than in the other mountainous zone, but in a country of dry summers and severely cold winters tree-life is bound to be still poorly developed, and scrub woodlands rather than forests are to be expected. As everywhere else in the mountainous land, these woodlands consist mainly of the oak tree, which may be regareded as the national tree of Kurdistan. In the higher slopes, up to the snow-line, alpine prairies, also of a rather poor nature, permit summer grazing for the flocks of the transhumant Kurds who both enjoy and endure life in this subregion of scenic structural landforms, invigorating climate and limited resources.

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Geli Ali Bey gorge. Note the steep rocky gorge wall and long icicles hanging from the rocks.

The «Tepe» of Arbil.

Donkeys and mules heavily loaded with fuelwood near Shaqlawa.

Geli Ali Bey gorge.

Geli Ali Bey gorge.

The Shaqlawa synclinal plain. An anticlinal mountain rises in the background.

A Kurdish farmer.

View from near Harir village looking towards the synclinal basin of the area. Sheep grazing in the foreground; houses and tents in the middle ground; an anticlinal ridge in the background.

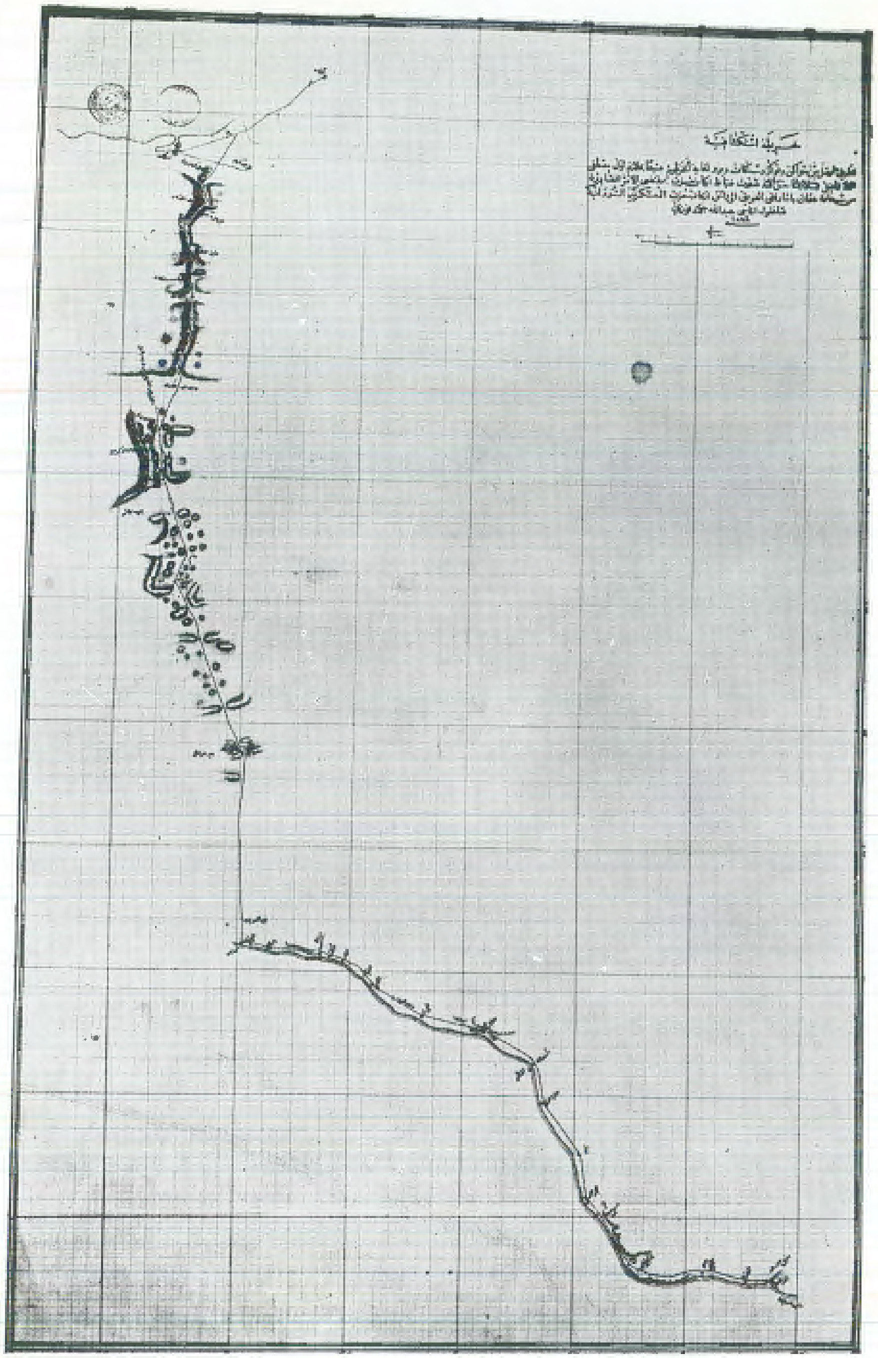
Three Kurds and the writer. Note also the structurally determined convexity of the summits in the background.

Part of a Kurdish village built on the lower slope of a mountain.

The hilly country east of Kirkuk.

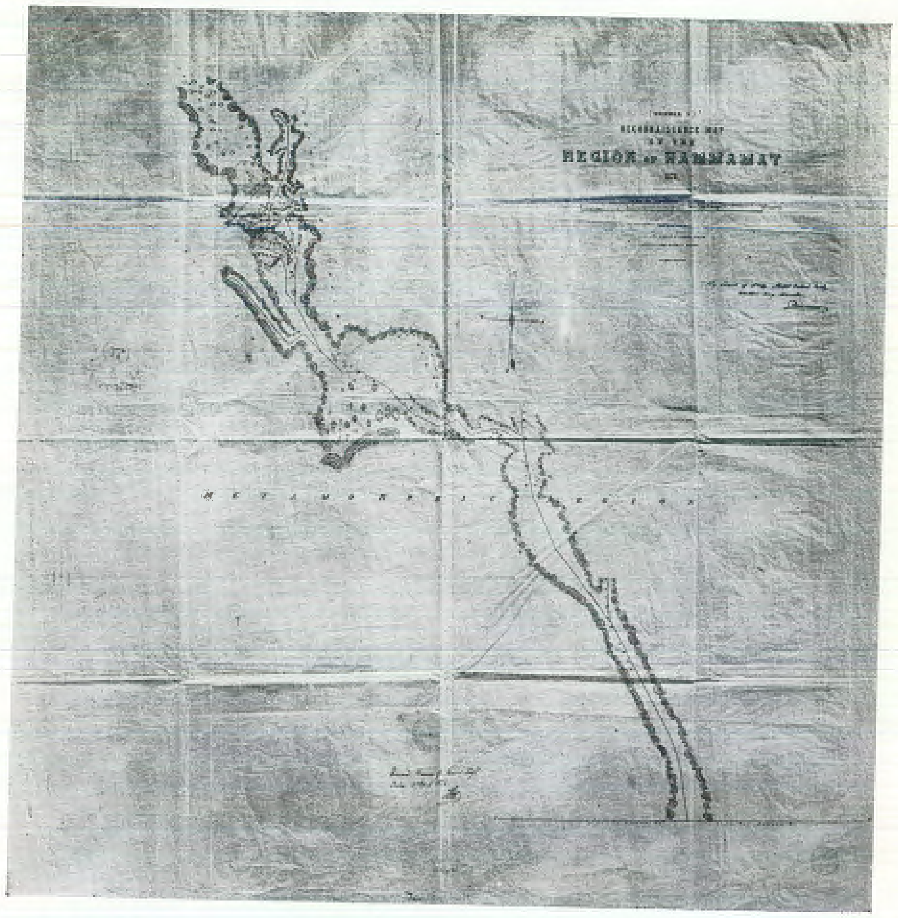
A breached part of the crest of the Hamrin anticline near its southern extremity.

لوحة ٤



٤ – خريطة استكشاف الطريق الموصل من سواكن وتوكر وبربر الى الخرطوم ، عملت بمعرفة الملازمين مصطفى فاضل وحسن صفوت باشراف الصاغ ا. ج. عبد الله فوزى ، عام ١٨٧٨ ،
م. ر. ١/٦٠٠,٠٠٠

٣ – خريطة استكشاف الطريق بين هند وبنا ، عملت بمعرفة القومندان ا. ج. محمد مختار بأمر القائمقام جريفز رئيس بعثة الاستكشاف . رسمها الملازم الثانى حسين غالب عام ١٨٧٨ م.



٢ – خريطة استكشاف منطقة الحمامات عام ١٨٧٥ ، عملت بمعرفة الملازم الأول ا. ج. عبد الفتاح فتحى باشراف القائمقام ميشيل م. ر. ١/١٠,٠٠٠

لوحة ١

١ – ميناء السويس موضحاً به الأعماق ، عملت بمعرفة الضابط درويش فهمى بادارة الجنرال ستون
نقلا عن رسم لدوسو بك فى فبراير ١٨٧١ م. ر. ١/٢٠,٠٠٠

١٤ — ادوارد أوسكارثيودورشنيتزر المعروف بأمين باشا (١٨٤٠ — ١٨٩٢) طبيب وموظف ألمانى يهودى ، اعتنق المسيحية ، إلتحق بخدمة تركيا ، دعاه جوردون للخدمة فى خط الاستواء (١٨٧٦) ، وعينه كبيراً لأطبائها ثم بعثه إلى يوجندة وأونيورو ، عين مديراً لمديرية خط الاستواء (١٨٧٨ — ١٨٨٩) أنقذه ستانلى المستكشف وأعاده إلى زنجبار ثم أنعم عليه برتبة اللواء والباشوية ، إلتحق بخدمة ألمانيا فى أفريقيا الشرقية .

١٥ — شارلز إيفرسون جريفز (١٨٣٧ — ١٨٩٦) : ضابط أميركى ، إلتحق بخدمة الحكومة المصرية وأرسل إلى مصوع فى أثناء الحرب المصرية الحبشية (١٨٧٥ — ١٨٧٦) ، أوفد فى عدة بعوث علمية إلى ساحل الصومال ، استقال من الجيش المصرى (١٨٧٨) .

١٦ — راجع مجلة أركان الحرب — السنة الثالثة — مجلد ١ ، ج ١ ، القاهرة (١٨٧٦) ، ص ٢٩ — ٣٥ ، وانظر مقال جريفز عن رأس جردفوى والفنار فى مجلة الجمعية الجغرافية ، المجموعة رقم ٢ ، عدد ٧ ، ص ٣٤٩ ، والمجموعة الأولى عدد ٨ ، ص ٢٩ — ٤٣ ، وعدد ٩ و ١٠ ، وانظر

Mitchell, L. H. : Journal officiel de la reconnaissance géologique et minéralogique entre Zeilah et Tadjoura.

فى المجلة الجغرافية ، المجموعة الثالثة ص ١٨٥ — ٢٥٥

ومقال محمد مختارعن بلاد الجاديبورسى ، مجموعة ١ ، عدد ٧ ، ص ٥ — ١٧

ومقال جنرال ستون عن طبوغرافية وجغرافية البلاد الواقعة بين ساحل البحر الأحمر وهضبة الحبشة ، المجموعة الأولى ، العددان ٩ و ١٠ ، ص ٤٣ — ٧٦

١٧ — جوهان ألبرت فرنر مونزنجر (١٨٣٢ — ١٨٧٥) مكتشف وإدارى سويسرى ، درس العربية ثم انضم إلى دار أعمال تجارية يسرت له الرحلة إلى كوردفان وبوغوص وثغور البحر الأحمر ، عين (١٨٦٤) قنصلا فرنسياً فى مصوع وتردد كثيراً على المدن الحبشية وتزوج من إحدى بنات بوغوص ، رحل إلى أوروبا وعاد ثانية ليشغل منصب القنصل البريطانى فى مصوع ،

وفى عام ١٨٧١ عينته الحكومة المصرية حاكماً لمدينة مصوع . قام بعدة إصلاحات فى تلك المنطقة وضم إليها بعض الأراضى المجاورة ، لقى حتفه قبيل الحرب المصرية الحبشية (١٨٧٥) ومعه زوجته وطفلته ومساعده هاجنميخر فى أثناء رحلتهم فى بلاد الهوسى .

١٨ — هنرى فردريك ماكيلوب باشا (١٨٢٥ — ١٨٧٩) أحد رجال البحرية البريطانية ، إلتحق بالحكومة المصرية ليشغل وظيفة ناظرميناء الاسكندرية ثم عين مراقب عام للمنائر والموانى ، وقاد سفائن البحر الأحمر فى أثناء الحرب الحبشية المصرية ، وصل أسطوله (١٨٧٥) إلى مصب نهر جوبا على ساحل الصومال حيث نزلت الجنود المصرية فى كسمايو ، ولأسباب سياسية استدعى الخديو اسماعيل هذه البعثة على أثر احتجاج الحكومة البريطانية . مات فى القاهرة عام ١٨٧٩

١٩ — راجع وصف المنطقة بين زيلع وهرر لبونولا فى مجلة الجمعية الجغرافية المجموعة ٢ ، ص ٤٦١ و ٤٦٢

وانظر مقال عبد الله فوزى : زراعة وتجارة البن فى هرر فى مجلة الجمعية الجغرافية ، المجموعة الثانية ، ص ٤٨٠ — ٤٨٣

جوردون باشا : خطاب لحسنى باشا عن الحملات المصرية فى أفريقيا فى مجلة الجمعية الجغرافية ، المجموعة الثالثة ، ص ٦٧ — ٨٢

محمد مختار : مقال عن ملاحظات فى بلاد هرر ، المجموعة الأولى ، عدد ٤ ، ص ٣٥١ — ٣٩٧ ، وعدد ٥ ، ص ١٤

نادى باشا : ملاحظات عن هرر فى المجموعة الثانية من المجلة الجغرافية ، ص ٤٦٢ — ٤٦٤

ستون باشا : ملاحظات عن جغرافية الحبشة عن تقارير ضباط أركان الحرب ، المجموعة الأولى ، عدد ٢ ، ص ٣٨ — ٣٩

دكتور عبد الرحمن زكى

من المجلة الجغرافية الخديوية ص ٤٨٩ — ٥٦٨ ، وانظر تقرير بوردى عن أعمال البعثة فى مجلة الجمعية الجغرافية الخديوية مجموعة ٢ ، عدد ٦ ، ص ٤٣١ — ٤٤٥ وانظر أيضاً تقرير جيولوجى للمنطقة الواقعة بين برنيقة وبربر لكولستون ، مجموعة ٢ ، ص ٥٧٣ — ٥٩٧ ، وانظر مقال ميتشيل عن معادن الذهب فى الحمامات ، مجلة الجمعية الجغرافية ، مجموعة ١ ، عدد ٦ .

٥ — ليبنز ميتشيل (١٨٣٤ — ؟) : مهندس مناجم أميركى ، إلتحق ببعثة للكشف عن المعادن فيما بين النيل والبحر الأحمر (١٨٧٤) ووصل إلى مصوع (١٨٧٧) للبحث عن المعادن فى المنطقة المجاورة للحبشة . وقع فى أسر الأحباش وبقى فى قبضتهم مدة ثم انطلق سراحه ، كتب مذكراته (١٨٧٨) .

٦ — صمويل هنرى لوكيت (١٨٣٧ — ١٨٩١) : ضابط أميركى إلتحق بخدمة الجيش المصرى (١٨٧٥) وأرسل إلى مصوع للقيام بأعمال جغرافية ثم ضم إلى هيئة أركان حرب حملة راتب باشا فى الحبشة (١٨٧٥) ، اشترك مع طائفة من الضباط المصريين لرسم خريطة أفريقية الكبرى . عاد إلى موطنه (١٨٧٨) .

٧ — راجع تقرير عن كوردفان الشمالية والوسطى فى مجلد واحد — مطبعة أركان الحرب باللغة الإنجليزية ، وانظر التقرير الخاص بوصف الطريق من الدبة إلى الأبيض فى العدد الرابع من القسم الثانى بمجلة الجمعية الجغرافية عام ١٨٨٨ ، والتقرير العام عن مديرية كوردفان — مطبعة عموم أركان الحرب عام ١٨٨٧ ؟ باللغة الإنجليزية ، وانظر الرسالة عن المنطقة الكائنة بين داره وحفرة النحاس للكولونيل بوردى فى العدد ٨ ، المجموعة ١ من مجموعة الجمعية الجغرافية الخديوية وكتاب مصر والجغرافيا (بنولا بك) ص ٤٩ — ٥٣ .

٨ — رالى ادوارد كولستون (١٨٢٥ — ١٨٩٦) : ضابط أميركى إلتحق بهيئة أركان حرب الجيش المصرى عام ١٨٧٤ برتبة الأميرالاى ، وقاد بعثتين جغرافيتين الأولى فى صحراء النوبة والثانية فى كوردفان ، وكتب عدة تقارير طبية عنهما . استقال من عمله (١٨٧٨) وعاد إلى وطنه .

٩ — انظر شايبه لونج :

Notes sur les nègres qui habitent le pays du Bahr el-Abiad jusqu'à l'Equator et à l'ouest du Bahr el-Abiad jusq'à Makraka Niam-Niam.

المجموعة الأولى ، العدد ٢ ، المجلة الجغرافية ص ٢٢٤ — ٢٣٤ ، وانظر مقال لينان دى بلفون عن رحلته فيما بين فاتيكو وعاصمة ميتسا ملك يوجندة فى ١٨٧٥ المجموعة الأولى ، العدد ١ ، المجلة الجغرافية ص ١ — ١٠٤ مصحوبة بخريطة .

١٠ — شارل شايبه لونج (١٨٤٢ — ١٩١٧) : ضابط أميركى إلتحق بخدمة الحكومة المصرية (١٨٧٠) ، رافق جوردون حاكم مديرية خط الاستواء (١٨٧٤) كلفه بزيارة يوجندا التى كان يزمع ضمها إلى مصر ليكتب تقريراً عنها ، كشف المناطق المحيطة ببحيرة فكتوريا وكيوجا (بحيرة ابراهيم)، كشف بلاد الأزاندا (١٨٧٥) ، تقاعد عام ١٨٧٧ ، ألف عدة كتب .

١١ — لويس لينان دى بلفون (١٨٠٠ — ١٨٨٣) : مهندس ومكتشف فرنسى إلتحق بخدمة الوالى محمد على . رافق الحملة العسكرية المصرية إلى السودان (١٨٢١ — ١٨٢٣) استقال فترة من الزمن وعاد ثانية إلى خدمة مصر (١٨٣١) ، وقام ببحثين بالصحراء السودانية وقدم عدة مشروعات للرى . عين ناظر الأشغال (١٨٦٩) ومنح رتبة الباشوية (١٨٧٣) .

١٢ — رومولوجيسى باشا (١٨٣١ — ١٨٨١) إدارى ممتاز ، رافق جوردون عام ١٨٧٤ ، طاف حول شواطىء بحيرة ألبرت (١٨٧٦) ثم استقال وعاد إلى إيطاليا . رجع إلى السودان (١٨٧٧) لكشف حوض النيل الأزرق ثم عين حاكماً عاماً للسودان ثم مديراً لبحر الغزال ، واشترك فى عدة معارك ضد سليمان الزبير رحمة فى جنوبى دارفور ، مات فى السويس .

١٣ — شارلز جورج جوردون (١٨٣٣ — ١٨٨٥) : ضابط وإدارى بريطانى ، قاد حملة فى الصين ، عين حاكماً عاماً للسودان (١٨٧٧ — ١٨٨٠) وفى أثناء ثورة المهدى بالسودان قتل على درج قصره فى الخرطوم (١٨٨٥) ، اشترك فى عدة كشوف جغرافية أثناء توليه منصب مدير إقليم خط الاستواء .

٩ — مدينة هرر[1] — م . ر. ١/٢٠٠٠

محمد مختار ، ١٨٧٦

١٠ — خريطة استكشافية للطريق بين مصوع إلى قرع — م . ر. ١/٥٠,٠٠٠

لوكيت[2] .

١١ — قلعة حسن باشا المواجهة لقياخور — م . ر. ١/٥٠٠

لوكيت ، ١٨٧٦

١٢ — قلعة حسين باشا فى أنباتوفان — م . ر. ١/٢٥٠

لوكيت ، ١٨٧٦

١٣ — قلعة قرع — مسقط أفقى وقطاع رأسى — م . ر. ١/٥٠٠

كولونيل ديريك ودرهولتز والملازمان عزمى ورفعت[3] ، ١٨٧٦ — ١٨٧٧ ؟

١٤ — موقع دفاعى فى جوتوملو — م . ر. ١/٥٠٠

رمزى (مصطفى أو حسين ؟) ، ١٨٧٧ ؟

١٥ — خريطة استكشافية لحكمدارية هرر وملحقاتها — م . ر. كل ٩,٥ ملليمتر لساعة واحدة

بكباشى ا . ح . أحمد وعدى والملازم عبد الكريم عزت ، ١٢٩٩ هـ — ١٨٨١ [المتحف الحربى] .

ومبيناً عليها قطاع طولى للطريق الموصل من زيلع إلى هرر ماراً بأراضى العيسى .

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(١) توجد خريطة أخرى عن مسطح مدينة هرر وجانب من البساتين المجاورة لها أخذت بالبوصلة بمعرفة كل من اليوزباشى عبد الكريم عزت والقائمقام أحمد وعدى من أركان حرب حكمدارية هرر — ١٢٩٩ هـ — ١٣٠٠ هـ [المتحف الحربى] .

(٢) توجد خريطة أخرى لهذا الطريق عملها ميتشيل .

(٣) توجد خرائط كثيرة عسكرية للحملة المصرية فى الحبشة قام بعملها ضباط أركان الحرب أثناء القتال .

تعليقات ومراجع

١ — إيراستوس جارو بوردى (١٨٣٨ — ١٨٨١) : كولونيل أميركى ، إلتحق بخدمة الحكومة المصرية عام ١٨٧٠ فى هيئة أركان الحرب ، وقاد بعثة جغرافية للكشف عن المنطقة بين النيل والبحر الأحمر ، وفى عام ١٨٧٣ كشف المنطقة بين برنيقة وبربر ، وفيما بين عام ١٨٧٤ و ١٨٧٦ ترأس جماعة من الضباط لكشف المنطقة بين دنقلة والفاشر وحفرة النحاس ودارفور ، رقى إلى رتبة أميرالاى ثم أستغنى عن خدمته فى عام ١٨٧٨

٢ — هنرى جوسلى براوت (١٨٤٥ — ١٩٢٧) : إلتحق بخدمة الحكومة المصرية فى عام ١٨٧٢ برتبة بكباشى بسلاح المهندسين . اشترك مع كولستون فى بعثة كشفية فى كوردفان (١٨٧٥) ترأس البعثة المذكورة عقب مرض كولستون . كتب تقارير مفيدة عن كوردفان ودارفور وعن نتائج أعمال البعثة ، نقل إلى مديرية خط الاستواء وعين مديراً لها سنة ١٨٧٦ ، قام بعدة أعمال فنية ثم استقال وعاد إلى الولايات المتحدة .

٣ — ألكسندر ماكوب ماسون (توفى سنة ١٨٩٧) : ضابط بحرى أميركى ، إلتحق بخدمة البحرية المصرية عام ١٨٧٠ ثم اشترك مع الضابط بوردى فى الأعمال الكشفية (١٨٧٤) . عين فى منصب مدير خط الاستواء (١٨٧٦ — ١٨٧٧) ، وفى تلك المدة كشف منطقة النيل الأبيض بين دوفيلية وبحيرة ألبرت ، وفى عام ١٨٧٧ قام بكشف محدود فى تلك البحيرة فى أعقاب جيسى ، واكتشف نهير سمليكى . استقال عام ١٨٧٨ والتحق بخدمة إدارة المساحة ونهض بعدة أعمال طيبة ، وفى عام ١٨٨٤ عين حاكماً لمصوع ثم تقاعد (١٨٨٥) ورحل إلى الولايات المتحدة . نشر مقالا عن استكشاف بحيرة ألبرت فى المجلة الجغرافية .

٤ — راجع رسالة كولستون بعنوان يوميات الرحلة من قنا إلى برنيقة وبربر والعودة عن طريق صحراء كوروسكو المنشورة فى العدد التاسع من القسم الثانى

٩ — بربرة — المستشفى — م . ر. ١/١٠٠
يوزباشى نظمى ، ١٢٩٣ — ١٨٧٦

١٠ — خريطة توضح تصميم طريق خط أنابيب المياه بين مدينة بربرة إلى جبل ضوبار — م . ر. ١/١٠٠٠
يوزباشى عبد الرازق نظمى بأمر اللواء رضوان باشا ، ١٢٩٣ — ١٨٧٧
[المتحف الحربى] .

١١ — المنطقة المطلة على رأس جردفوى — ١/٥٠,٠٠٠
محمد مختار ، ١٨٧٨

١٢ — خريطة خليج جرودفوى — م . ر. ١/٢٠,٠٠٠
كولونيل جريفز والملازم مصطفى عاطف ، ١٨٧٨ [المتحف الحربى] .

١٣ — خريطة مدخل وادى تهيمة من الجنوب — م . ر. ١/٥٠٠٠
بأمر كولونيل جريفز وعمل محمد مختار ومحمد عزت وحسين غالب ، ١٨٧٨ [المتحف الحربى] .

١٤ — منشآت الحكومة فى بربرة
بهرام ، ١٢٩٦ — ١٨٧٨

١٥ — خريطة استكشاف المنطقة بين هند وبنا — م . ر. بالأميال البحرية
محمد مختار وحسن غالب بأمر الكولونيل جريفز ، ١٨٧٨ [المتحف الحربى].

١٦ — خريطة تبين بناء فنار وثكنة فى جردفوى — م . ر. ١/١٠٠
مورى بك ، ١٨٨٠

١٧ — ميناء اسماعيل على المحيط الهندى — م . ر. ١/٢٥,٠٠٠
ماكيللوب (١٨) .

١٣ — الحبشــــة (١٩)

١ — خريطة توضح حدود الحبشة
تعليمات اللواء راشد كمال قائد حدود الحبشة وبمعرفة ضباط أركان حربه وباشر طبعها ونشرها يوزباشى ا . ح . عبد السلام زكى
[دار الكتب رقم ٢٩]

٢ — الحبشة والبلدان المجاورة — م . ر. ١/١٠٠,٠٠٠
لوكيت ، ١٨٧٥

٣ — سهل قلعة وقرع — م . ر. ١/٢٥,٠٠٠
لوكيت ، ١٨٧٥

٤ — سهل إيليت
لوكيت وبليغ ، ١٨٧٦

٥ — كروكى للطريق الحربى بين مصوع وقياخور — ١/٥٠,٠٠٠
لوكيت عن خريطة سابقة ، ١٨٧٦ [المتحف الحربى] .

٦ — سنانة وما جاورها — ١/١٥٠,٠٠٠
لوكيت ، ١٨٧٦

٧ — خريطة استكشافية للطريق الموصل من جبل بامبا إلى قرع — ١/٥٠,٠٠٠
لوكيت ، ١٨٧٦

٨ — حكمدارية مدينة هرر — م . ر. ؟
القومندان محمد مختار والصاغ عبد الله فوزى بأمر اللواء محمد رؤوف مطبوعة وملونة ، ١٨٧٦

١٠ – خريطة استكشافية لمديريات خط الاستواء والنيل بين دوفيلية وماجنجو – م . ر. ٣٦٢,٠٠٠/١
كولونيل ميسون بك ، ١٨٧٧

١١ – بحيرة ألبرت نيانزا – م . ر. ؟
كولونيل ميسون بك ، بأمر جوردون حاكم السودان (١٣) ، ١٨٧٧ (الجمعية الجغرافية) .

١٢ – منابع النيل فى مديريات خط الاستواء – م . ر. ١٠٠,٠٠٠/١
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١٣ – استكشاف النيل من حنك إلى ملك الناصر – م . ر. ١٥٧,٠٠٠/١
كولونيل ماسون بأمر جوردون باشا ، ١٨٧٨ [المتحف الحربى] .

١٤ – مديريات خط الاستواء :
أمين باشا (١٤) مدير المديرية ، ١٨٨٢ – ١٨٨٥

١٥ – محطة دوفيلية العسكرية (مديرية خط الاستواء)
نقلها عن الأصل عبد السلام زكى ، ١٨٩٠

١١ – مصوع وما جاورها على البحر الاحمر

١ – مصوع وما جاورها (٣ أقسام) – م . ر. ٥٠٠٠/١
لوكيت .

٢ – ميناء مصوع ورصيفها – م . ر. ١٥ ملليمتر = متر
بكباشي جريفز (١٥) .

٣ – مشروع مد المياه لمصوع – م . ر. ١٠٠/١
ثابت ، ١٨٧٩

٤ – قصر الحاكم العام = م . ر. ١٠٠/١
حسين رمزى ؟

٥ – خليج عصب = ١٠٠,٠٠٠*١
الضابط فوزى ، ١٨٨٠

١٢ – الصومال والمحيط الهندى (١٦)

١ – مدينة زيلع وما جاورها – م . ر. ٥٠٠٠/١
القومندان محمد مختار ، ١٨٧٥

٢ – تاجورة – م . ر. ٥٠٠٠/١
عزت ، ١٨٧٥

٣ – الطريق من تاجورة إلى العوسى – م . ر. ٣١٦,٨٠٠/١
عزت .

٤ – بربرة مبين عليها المسجد والمستشفى والثكنات – م . ر. ١٠٠/١
عبد الرازق نظمى ، ١٢٩٢ هـ – ١٨٧٥

٥ – خريطة أراضى زنجبار (مطبوعة)
قائمقام محمد صادق ، ١٢٩٢ هـ – ١٨٧٥ [دار الكتب رقم ٨] .

٦ – الطرق إلى تاجورة – م . ر. ٣٣٣,٣٣٣/١
مونزينجر (١٧) ، ١٨٧٦

٧ – بلاد الصومال – م . ر. ٥٠٠,٠٠٠/١
محمد كانى ، ١٨٧٦

٨ – خريطة منطقة من مملكة عادل بين زيلع وهرر – م . ر. ٩٦٤,٠٠٠/١
محمد مختار ، ١٨٧٦

٦ – مدينة الأبيّض عاصمة كردفان – م . / . ١/١٠,٠٠٠
هيئة أركان الحرب ، ١٨٧٥

٧ – خريطة استكشاف الطريق من الأبيّض إلى الفاشر – م . / . ١/٥٠٠,٠٠٠
القومندان براوت والملازمان محمد ماهر وخليل فوزى ، ١٨٧٦

٨ – خريطة استكشافية للطريق من داره إلى حفرة النحاس – م . / . ١/٤١,٢٢٢ (قسمان)
بوردى ، ١٨٧٦

٩ – خريطة استكشافية للأقسام الشمالية الغربية من دارفور الخديوية
٣ ستى = ساعة مسير على ظهر الجمل
بوردى ، ١٨٧٦

١٠ – خريطة منطقة جبل مرة تبين الطريق الذى سلكه براوت – م . ر. ١/٥٠٠,٠٠٠
١٨٧٦

١١ – خريطة لمشروع السكة الحديدية فى دارفور من أبو جوسى إلى أم بدر ومنها إلى الفاشر
هيئة أركان الحرب ، ١٨٧٦

١٢ – خريطة الطريق من الأبيّض إلى الفاشر – م . ر. ١/١٦٦,٦٦٦
براوت ، ١٨٧٦

١٣ – خريطة من فوجة إلى الأبيّض – ١/٥٠٠,٠٠٠
براوت ، ١٨٧٧

وهناك ثلاث خرائط أخرى قام بعملها القومندان بوردى فى هذه المنطقة .

١٠ – بحر الغزال ومديريات خط الاستواء (٩)

١ – خريطة المنطقة بين جند وكرو إلى أمالى – م . ر. ١/٢٢٢,٢٥٠
هيئة أركان الحرب ، ١٨٧٤

٢ – خريطة المنطقة من جندوكرو إلى فاشوده – م . ر. ؟
واطسون ، ١٨٧٤

٣ – الطريق الموصل من جند وكرو إلى خط الاستواء ذهاباً وإياباً
أميرالاى شاييه لونج بك (١٠) ومصطفى صدقى ، ١٨٧٤
مطبعة أركان الحرب [دار الكتب رقم ١٠] .

٤ – كروكى للطريق بين الرجاف وفاتيكو – ١/٥٠٠,٠٠٠
لينيان دى بلفون (١١) ، ١٨٧٥

٥ – خريطة استكشافية بين الرجاف وبحيرة فكتوريا
لينيان دى بلفون ، ١٨٧٥

٦ – النيل بين الرجاف وماكيديه – م . ر. ١/١٢٦,٧٢٠

٧ – النيل من جندوكرو إلى بحيرة ألبرت نيانزا
هيئة أركان الحرب ، ١٨٧٦

٨ – بحيرة ألبرت نيانزا – م . ر. ١/٦٠٠,٠٠٠
جيسى بك (١٢) بأمر الحكومة المصرية ، ١٨٧٦

٩ – خريطة النيل بين دوفيلية وبحيرة ألبرت نيانزا – م . ر. ١/٩٠٠,٠٠٠
بأمر جوردون باشا إلى جيسى بك ، أبريل ١٨٧٦

٣ ــ مصر وممتلكاتها ــ ٢ سنتى = ٥٠ ميل
هيئة ا . ح .

٤ ــ خريطة عامة للسودان ــ ١/٣٠٠,٠٠٠
هيئة ا . ح . ، ١٨٨٠

٧ ــ دنقلة وبربر والخرطوم

١ ــ مخازن البارود فى بربر ــ م . ر. ١/١٠٠
الملازم مصطفى فاضل ، ١٨٧٨

٢ ــ مدينة بربر ــ م . ر. ١/٥٠٠٠
مصطفى فاضل ، ١٨٧٨

٣ ــ مخازن الذخيرة ومستشفى بربر ــ م . ر. ١/١٠٠
مصطفى فاضل والملازم الثانى حسن صفوت ، ٢٣ أبريل ١٨٧٧

٤ ــ الخرطوم وحصونها ــ ١/٥,٠٠٠
؟ ؟ . .

٨ ــ السودان الشرقي وسواكن

١ ــ خريطة الطريق من سواكن إلى بربر وأقسامها ــ م . ر. ١/٢٠٠
حمدى ، ١٢٩٠ هـ ــ ١٨٧٣

٢ ــ سنار العليا ــ م . ر. ١/٦٦٦,٦٦٦
لوكيت (٦) ، ١٨٧٥

٣ ــ خريطة استكشافية للطريق من سواكن إلى سنكات ــ م . /. ؟
بكباشى ا . ح. محمد مختار والصاغ ا . ح . عبد الله فوزى والملازم عبد الحليم حلمى بأوامر اللواء محمد رؤوف باشا ، ١٨٧٥.

٤ ــ خريطة استكشافية للطريق من سواكن إلى بربر ــ م . ر. ١/٤٠٠,٠٠٠
القومندان براوت والملازم الثانى محمد ماهر ، ١٨٧٥ [المتحف الحربى]
مطبعة أركان حرب الجيش (دار الكتب رقم ١١) .

٥ ــ خريطة استكشافية للطريق الموصل من سواكن وطوكر وسنكات وبربر إلى الخرطوم ــ م . /. ١/٦٠٠,٠٠٠
الملازم الأول مصطفى فاضل وحسن صفوت تحت إشراف عبد الله فوزى ، ١٨٧٨ [المتحف الحربى] .

٩ ــ السودان الغربى (٧)

١ ــ خريطة للطريق بين دنقلة العجوز إلى الفاشر (دارفور) ؟
القومندان بوردى ، ١٨٧٥

٢ ــ خريطة من أم بدر إلى أرجود ــ م . /. ١/٨٠٠,٠٠٠
بوردى واليوزباشى صبرى ، ١٨٧٥

٣ ــ خريطة الطريق بين الخرطوم والأبيّض ــ م . /. ١/٨٠٠,٠٠٠
براوت والملازم محمد ماهر ، ١٨٧٥ [المتحف الحربى] .
طبعت بمطبعة أركان حرب الجيش [دار الكتب رقم ٤] .

٤ ــ خريطة الطريق من الدبة إلى الأبيّض ــ م . /. ١/١,٠٠٠,٠٠٠
كولونيل كولستون (٨) والصاغ أحمد حمدى وأحمد نظمى ، أكتوبر ١٨٧٥

٥ ــ خريطة استكشافية لمديرية كردفان ــ م . /. ١/١٥٠,٠٠٠
براوت والضابط عبد الله فوزى وأحمد حمدى ، ١٨٧٥ ــ ١٨٧٦
وهناك خريطة لكوردفان مطبوعة للقومندان براوت .
م . /. ١/٨٠٠,٠٠٠

١٣ — المنطقة بين النيل وبحيرة النطرون — (بالخطوة)
القومندان محمد مختار ، ١٨٧٧

١٤ — المنطقة الشمالية من مديريتي الغربية والدقهلية — ١/١٠٠,٠٠٠
محمود الفلكي ، ١٢٩٩ هـ — ١٨٨١

٤ — مصر الوسطى والعليا

١ — ثكنات الخيالة فى الفيوم — ١/١٠٠٠
الملازم حمدى ، ١٢٨٤ هـ — ١٨٦٧

٢ — خريطة استكشافية للطرق الموصلة بين الزعفرانة وبنى سويف — ١/٢٥٠
بوردى ، ١٨٧١

٣ — خريطة للطريق بين أسيوط إلى عين اللجبة ومن سليمة إلى الآبار — ١/٥٠٠,٠٠٠
درهولتز والملازم محمد عزمى ، ١٨٧٥ [المتحف الحربى] .

٤ — خريطة تبين الطريق بين إسنا إلى الواحات الخارجة — م . ر. ١/٦٣,٣٦٠ [المتحف الحربى] .

٥ — خريطة للطريق من مدينة الفيوم إلى سيوة
ماسون (٣) ، ١٨٧١ [المتحف الحربى] .

٥ — منطقة البحر الاحمر (٤)

١ — خريطة استكشافية للطريق بين جبل الغريب (الزيت) ورأس جسمة وقنا — بوصة = ٦ ميل .
بوردى ، ١٨٧١

٢ — استكشاف منطقة وادى الحمامات لبيان محاجر الجرانيت وعروق الكوارتز — م . ر. ١/١٠,٠٠٠
الكولونيل ميتشل (٥) والملازم عبد الفتاح فتحى ، ١٨٧٥ [المتحف الحربى] .

٣ — خريطة جيولوجية ومسقط رأسى للارتفاعات — م . ر. ١/٨٠,٠٠٠ ، ١/٤,٠٠٠
الكولونيل ميتشيل ، ١٨٧٥

٤ — المنطقة الواقعة شرقى خليج السويس (بترا العربية) — ١/٣٠٠,٠٠٠
ميجورهوايت والملازم الثانى اسماعيل صبرى ، ١٨٧٥

٥ — خريطة استكشافية لمنطقة الرودسية — ٧ بوصة = ١٢ ميل
ميتشيل والملازم عبد الفتاح فتحى ، ١٨٧٥

٦ — صهاريج المياه القريبة من برنيقة على البحر الأحمر — ١/٢٥٠
كولونيل بوردى ، التاريخ ؟

٧ — آبار المياه فى المنطقة بين قنا وبرنيقة
الملازم اسماعيل صبرى ، التاريخ ؟

٦ — السودان (عامة)

١ — خريطة الجزء الشمالى الشرقى لأفريقية وبلاد العرب — ١/٥٦٠,٠٠٠
محمد عزمى وصبرى ، ١٨٧٥

٢ — مصر وأفريقية الاستوائية — ١/١٠٠,٠٠٠
هيئة ا . ح . ، ١٨٧٥ — ١٨٧٦

٦ — خريطة للأراضى الممتدة بمحاذاة قناة الاسماعيلية إلى الشمال — ١/٢٠٠٠
نظمى ، ١٨٧١ [المتحف الحربى] .

٧ — العريش وما جاورها — م . ر. ١/٨٠٠٠
القومندان براوت (٢) والقومندان محمد مختار والملازمون سليم وهبى
وبهرام وزكى ، ١٨٧٤

٨ — قلعة العريش — م . ر. ١/٢٠٠
براوت ، ١٨٧٤

٩ — ضواحى الاسماعيلية — م . ر. ١/٨٠٠٠
براوت ، ١٨٧٥ [المتحف الحربى] .

١٠ — الاسماعيلية — م . ر. ١/٢٠٠٠
عزى (مجهولة التاريخ) .

١١ — قناة السويس — (المقياس غير مدون)
براوت ، ١٨٧٥ [المتحف الحربى] .

١٢ — قسم من سهل جنيفة — م . ر. ١/٣٠,٠٠٠
عبد الله فوزى ، (التاريخ غير واضح) .

١٣ — ميناء السويس موضحاً به الأعماق — م . ر. ١/٢٠,٠٠٠
الملازم درويش فهمى ، نقلا عن خريطة لدوسوبك ، ١٢٨٧ هـ — ١٨٧١
[المتحف الحربى]

٣ — مصر السفلى

١ — الاسكندرية القديمة وضواحيها — م . ر. ١/٢٠,٠٠٠ :
محمود الفلكى ، ١٨٦٦ [الجمعية الجغرافية] .

٢ — ضواحى الاسكندرية — م . ر. ١/٢٠,٠٠٠
م . ا . الفلكى ، ١٨٦٦

٣ — سواحل الاسكندرية وطواحين الهواء — م . ر. ١/١٢,٨٧٥
م . ا . الفلكى ، ١٨٦٦

٤ — حصون القناطر الخيرية (القلاع السعيدية) — م . ر. ١/٥٠٠٠
حمدى ، ١٢٨٤ هـ — ١٨٦٧

٥ — ثكنات رشيد — م . ر. ١/٥٠٠
حمدى ، ١٢٨٥ هـ — ١٨٦٨

٦ — شبرا ورياح الشرقية — م . ر. ١/٤٠٠٠
عزى ، ١٢٨٩ هـ — ١٨٧٢

٧ — مديرية القليوبية — م . ر. ١/٢٠٠,٠٠٠
محمود الفلكى ، ١٨٧٢ [الجمعية الجغرافية] .

٨ — مديرية المنوفية ، البحيرة ، الغربية — م . ر. ١/٢٠٠,٠٠٠
محمود الفلكى ، ١٨٧٢ [الجمعية الجغرافية]

٩ — مديرية الشرقية والدقهلية — م . ر. ١/٢٠٠,٠٠٠
محمود الفلكى ، ١٨٧٢ [الجمعية الجغرافية] .

١٠ — مصر السفلى — ١/٢٠٠,٠٠٠
محمود الفلكى ، ١٨٧٢ [الجمعية الجغرافية] .

١١ — المنطقة بين بنها وبلبيس — م . ر. ١/٢٥,٠٠٠
عبد الحميد رشدى ، ١٨٧٣

١٢ — المنطقة بين القناطر الخيرية وتل البارود — ١/٥٠٠٠
السبكى ، ١٢٩١ هـ — ١٨٧٤

١ – القاهرة وضواحيها

١ – خريطة ثكنات الخيالة فى القبة – م . ر. ١/٥٠٠ :
أوتوزبير ٢٨٣ هـ – ١٨٦٦

٢ – ثكنات الحصوة فى العباسية – بدون مقياس
طاهر ١٢٨٤ هـ – ١٨٦٧

٣ – مخطط سور القاهرة – م . ر. ١/٥٠٠
هيئة أركان الحرب ١٢٨٥ هـ – ١٨٦٨

٤ – الثكنات التى اقترح تشييدها فى ميدان محمد على – م . ر. ١/٣٣٣
الملازم أحمد حمدى ١٢٨٥ هـ – ١٨٦٨

٥ – ثكنات الخيالة فى حى الظاهر – م . ر. ١/٥٠٠
الملازم حمدى ١٢٨٦ هـ – ١٨٦٩

٦ – الطريق الموصل بين الناصرة والعباسية – م . ر. ١/١٠,٠٠٠
الملازم عزى ١٨٧١

٧ – خريطة استكشافية للطريق بين كوبرى الجزيرة والأهرام – ١/٢٠,٠٠٠
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٨ – تخطيط عام لثكنات طره
الملازم فوزى ١٢٨٩ هـ – ١٨٧٢

٩ – خريطة استكشافية للمنطقة بين المنشية وطره – ١/٦,٠٠٠
الصاغ ا . ح . أحمد وعدى ، والملازمان مصطفى صدقى وفوزى ١٢٩٠ هـ – ١٨٧٣ [المتحف الحربى]

١٠ – خريطة لجزء من جبل المقطم – م . ر. ١/٢٠٠٠
الملازم حلمى ١٢٩١ هـ – ١٨٧٤

١١ – خريطة المنطقة من مخازن الذخيرة فى اسطبل عنتر (أثر النبى) إلى مخازن طره – م . ر. ١/٤٠٠٠
الملازم حمدى ١٢٩١ هـ – ١٨٧٤

١٢ – خريطة المنطقة بين حلوان والعباسية – م . ر. ١/٢٠,٠٠٠
الكولونيل بوردى (ا) والقومندان محمد لبيب والصاغ أحمد وعدى واليوزباشى أحمد حمدى وعبد الله فوزى والملازمون عبد الرازق نظمى واسماعيل نظيم ومحمد توفيق (التاريخ غير واضح) .

٢ – شرقى الدلتا

١ – ثكنات الخيالة فى رأس الوادى – م . ر. ١/١٠٠٠
الملازم حمدى ١٢٨٤ هـ – ١٨٦٧

٢ – ثكنات رأس الوادى – م . ر. ١/٥٠٠
نفعى ١٢٨٥ هـ – ١٨٦٨

٣ – ميناء السويس وحصونها – م . ر. ١/٥٠٠٠
اليوزباشى حمدى ١٢٨٧ هـ – ١٨٧٠

٤ – خريطة استكشافية للمنطقة بين القاهرة والسويس ، ومن السويس إلى عطيفة – ١/٨٠٤,٥٠٠
كولونيل بوردى ١٨٧١ [المتحف الحربى] .

٥ – خريطة الأراضى الواقعة بين قناة الاسماعيلية وطريق العباسية – م . ر. ١/٢٠٠٠
نظمى ، ١٨٧١

٢٣ — استكشاف المنطقة بين تاجورة وبلاد العيسى . قام به محمد عزت بأمر مُنزنجر باشا .

٢٤ — أرصاد بارومترية وترمومترية فى مديريات خط الاستواء وكوردفان ودارفور . . . الخ .

* * *

ولقد أوجزنا فى هذا المقال أهم ما رسمه ضباط القسم الجغرافى من الخرائط ، وما كتبوه من التقارير العامية التى نشرت فى المجلة الجغرافية أو جريدة أركان الحرب التى كانت تصدرها القيادة العامة للجيش . وجاءت تلك الخرائط الجديدة أكثر استيفاء للمعلومات من سابقاتها ، وقد عرف بعض العلماء الأجانب تلك الخرائط ، فقدروها وأثنوا على العمل الفنى الذى اضطلع به المصريون فى أجزاء القارة الأفريقية .

ولما تم هذا العمل الجبار فيما بين ١٨٧٤ و ١٨٨٢ ، أشرف القائد ستون فى القاهرة وبعض معاونيه على رسم خريطة كبيرة شاملة للأملاك المصرية مقياسها ١ / ١٠٠٠,٠٠٠ ، وكان الغرض من رسم هذه الخريطة جمع النتائج المتحصلة فى خلال ثمانى عشرة سنة انقضت كلها فى الفتوح والاستكشافات والبحوث والمراجعات ، وتزين هذه الخريطة اليوم بهو الجمعية الجغرافية المصرية ، ثم طبعتها مصلحة المساحة .

وقد كتب عنها القائد ستون : « إن مسطح الأرض التى شملتها تلك الأعمال الجغرافية يعادل مجموعة مساحة فرنسا وإمبراطوريتى ألمانيا والنمسا . وقد قضت هذه الأعمال على حياة ضابط وعالم ألمانيين واثنين من الفرنسيين ومثلهما من الأمريكيين ومثلهما من الطليان ومثلهما من المصريين ، وجميعهم استشهدوا فى سبيل الإخلاص للعلم . هذا غير من اختارهم الموت من الجنود البواسل الذين رافقوا الضباط وأهل الريادة ، فانهم لقوا حتفهم فى تلك البلاد المجهولة مثل زملائهم الذين صحبوا البعثات العلمية المحضة أيضاً » .

ولا شك أننا نرى من الواجب العلمى أن نثبت أسماء من تعاونوا على إخراج هذه الخريطة الفريدة من المصريين لكى تظل ذكراهم خالدة فى الميدان الجغرافى الأصيل :

عبد الحليم رشدى — يوسف حلمى — حسين مجدى — محمد لبيب — أحمد رائف — مصطفى رمزى — أحمد فايق — محمد نجيب — محمد عزت — خليل فوزى — عامر رشدى — محمد أمين — محمد بهرام — عبد الفتاح فتحى — محمد ماهر — أحمد فهمى — محمد رفعت — محمد كانى — أحمد طلعت — محمد عزمى — ابراهيم حلمى — خليل حلمى — سعيد ناصر — أحمد رمزى — حسن واصف — يوسف شفيق — عبد الحليم حلمى — اسماعيل صبرى — محمد ماهر — حسن حارس — يوسف ضياء — حسين رمزى .

* * *

حقاً ، ليس فى وسع أحد أن يتجاهل ما كان لمصر من شأن المتقدم وفضله فى ميدان الاستكشاف الجغرافى فى بلاد الصومال وأفريقية الشرقية وجميع أنحاء السودان وحوض النيل وصحارى مصر . هذه الأعمال الخالدة صفحة مجيدة تفاخر بها كل أمة حية . وهى جهود أعوام متتالية كما وصفها القائد ستون ، قامت على أكتاب الضباط المصريين فى صمت وهدوء وتواضع وكفاح مع الأمراض المتوطنة فى تلك الأقاليم البعيدة . . . والتى كانت فى يوم من الأيام قطعة من أرض الوطن [1] .

(1) Mustafa Amer : *Some unpublished Egyptian maps of Harrar* : Vol. 19 pp. 289-299, 1937. مجلة الجمعية الجغرافية المصرية

٢ – استكشاف النيل الأبيض من الخرطوم إلى غندوكرو ، وتعيين خمسة مواقع بالأرصاد الفلكية .

٣ – استكشاف بحيرة ألبرت عام ١٨٧٦ باشتراك جيسى الإيطالى .

٤ – تحقيق مجرى نهر النيل بين بحيرة فكتوريا ومرولى ، واستكشاف بحيرة ابراهيم .

٥ – استكشاف وإتمام خريطة الطريق بين الدبة وماطول وبين الدبة وأوبيال .

٦ – استكشاف كوردفان نتيجة عدة بعوث – وكتابة تقرير واف عنه بواسطة براوت .

٧ – استكشاف الطريق بين دنقلة على النيل والفاشر عاصمة دارفور برياسة كولونيل بوردى وزميله ماسون وخمسة ضباط مصريين .

٨ – استكشاف مديرية دارفور وقسم من منطقة دار فرتيت إلى حفرة دير النحاس وشيكا إلى الجنوب ، مع رسم خريطة لها وكتابة تقرير ضاف . قام بهذا العمل كولونيل بوردى وبراوت وماسون وتسعة ضباط مصريين .

٩ – استكشافات جيولوجية للمنطقة الواقعة بين الرودسية وقنا على النيل ، وللمنطقة الساحلية للبحر الأحمر بالقرب من مدينة القصير ، ورسم خريطة جيولوجية مليئة بالتفاصيل ، قام بجزء كبير من العمل الكولونيل ميتشيل وضابط مصرى من هيئة أركان الحرب .

١٠ – استكشاف المنطقة الواقعة جنوبى غربى زيلع بالقرب من تاجورة من الناحيتين الجيولوجية والطبوغرافية . ورسم خريطة مفصلة .

١١ – استكشاف ومسح المنطقة بين بربر وجبل ضوبار ورسم خريطة لها بمعرفة اليوزباشى عبد الرزاق نظمى وبعض زملائه .

١٢ – استكشاف وإتمام خريطة للطريق الصحراوى بين أسيوط وعين الأجية ، ونهض بهذا العمل الميجور درهولتز وضابط مصرى من هيئة أركان الحرب .

١٣ – رصد انتقال الزهرة فى ديسمبر سنة ١٨٧٤ فى الرجاف بالقرب من غندوكرو .

١٤ – تحقيق مجرى النيل فى المسافة بين شلالات كاما وبحيرة ألبرت .

١٥ – استكشاف أحد أفرع النيل التى تتصل به بالقرب من بحيرة ألبرت فى اتجاه الشمال الغربى .

١٦ – استكشاف أحد أفرع النيل من بحيرة ابراهيم فى الاتجاه الشمالى .

١٧ – استكشاف دقيق للنيل فيما بين فويرة ومرولى .

١٨ – استكشاف المنطقة بين النيل الأبيض بالقرب من غندوكرو وبلاد ماكياكا – نيام نيام .

١٩ – استكشافات فى علم النبات فى مديرية كوردفان ، قام بهذا العمل دكتور بفوند ، وكذلك فى القسم الأوسط لمديرية دارفور .

٢٠ – استكشاف وإتمام خريطة للمنطقة بين زيلع وهرر – إتمام خريطة هرر والأراضى المجاورة – قام به البكباشى محمد مختار والصاغ فوزى الملحقين بأركان حرب اللواء محمد رؤوف باشا .

٢١ – استكشافات طبوغرافية للمنطقة بين ساحل البحر الأحمر بالقرب من مصوع وهضبة الحبشة وعمل خريطة لها .

٢٢ – استكشاف وعمل خرائط لثغور كيسمايو على ساحل المحيط الهندى بالصومال . قام به الكولونيل وارد واليوزباشى صدقى وبعض الضباط المصريين .

مصر وفن الخرائط فى القرن التاسع عشر

بقلم

الدكتور عبد الرحمن زكى

قد يكون من العسير أن نعثر على عدد من الخرائط رسمها الجغرافيون المصريون فى خلال القرون العديدة التى سبقت القرن التاسع عشر، إذا استثنينا ماعثر عليه رجال الآثار من أوراق البردى التى أوضحت عليه كروكيات صغيرة، وما رسمه بعض جغرافى الإغريق أو العرب فى العصور الوسطى.

وفى الواقع أن نشأة فن الخرائط فى مصر ينسب إلى منتصف القرن التاسع عشر أو ثلثه الثانى. وإن كان قد عرف فى أوروبا قبل ذلك بوقت طويل.

ويمكن القول أن فن الخرائط الحديث فى مصر، بدأ حينما أعيد إنشاء هيئة أركان حرب الجيش فى الثلث الثانى من القرن التاسع عشر، وبين أقسام هذه الهيئة القسم الجغرافى. وكانت باكورة أعمال هذا القسم استكشاف ورسم الخرائط للصحارى المصرية وسواحل البحرين الأبيض والأحمر، وارتياد المناطق الفسيحة فى شرقى السودان وغربيه وحوض النيل، وكتابة التقارير العلمية عن تلك الأقاليم. وقد نهض بتلك الأعمال طائفة ممتازة من الضباط المصريين أمثال محمد مختار وعبد الله فوزى وأحمد حمدى وواصف ووعدى ومحمد صادق وغيرهم، وقد شاركهم فيها نخبة من الضباط الأمريكيين، نذكر منهم ستون وبوردى وبروت وكولستون وغيرهم.

ويتضح لنا من التقرير الذى كتبه الجنرال ستون رئيس البعثة الأمريكية فى ١٦ أكتوبر سنة ١٨٧٦، خلاصة النتائج الجغرافية والخرائط التى تمت بمعرفة ضباط بعثات الاستكشاف فى أواسط أفريقية فى خلال الأعوام ١٨٧٤ — ١٨٧٦، فاذا هى لا تقل عن سبعة وعشرين كشفاً نذكر منها(١):

١ — استكشاف دقيق لمنطقة النيل الأبيض من غندوكرو إلى بحيرة ألبرت.

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(١) Edwin de Leon : *The Khedieve's Egypt*. 3rd. ed. 1877. pp. 429-432.

القاهرة

مطبعة المعهد العلمي الفرنسي للآثار الشرقية

١٩٦٠

المرحوم الأستاذ الدكتور محمد عبد المنعم الشرقاوى

فى اليوم الثانى عشر من شهر نوفمبر سنة ١٩٦٠ توفى إلى رحمة الله الأستاذ الدكتور محمد عبد المنعم الشرقاوى رئيس قسم الجغرافيا بكلية الآداب بجامعة الأسكندرية ، ونائب رئيس الجمعية الجغرافية المصرية ، بعد حياة حافلة قضاها فى خدمة علم الجغرافيا .

ولد الأستاذ الدكتور الشرقاوى فى ٢٤ مايو سنة ١٩٠٢ ، وتلقى تعليمه العالى فى مدرسة المعلمين العليا وتخرج فيها سنة ١٩٢٥ ، وسافر فى بعثة علمية للتخصص فى الجغرافيا ، فالتحق بجامعة ليڤرپول بانجلترا ، وحصل منها على بكالوريوس شرف فى الجغرافيا من كلية الآداب فى سنة ١٩٢٩ وعلى درجة الماچستير فى الجغرافيا فى سنة ١٩٣١ .

وعين بعد عودته من انجلترا مدرساً للجغرافيا بكلية الآداب بجامعة القاهرة ، وواصل دراسته خلال عمله بالكلية إلى أن حصل على درجة الدكتوراه فى سنة ١٩٤١ ، وكانت أول درجة للدكتوراه فى الجغرافيا تمنحها جامعة القاهرة .

وتدرج الدكتور الشرقاوى فى وظائف التدريس بالجامعة إلى أن شغل كرسى الأستاذية بقسم الجغرافيا ، وعهد إليه برئاسة القسم فى سنة ١٩٤٨ ، ثم نقل فى سنة ١٩٥٤ إلى قسم الجغرافيا بجامعة الأسكندرية . وتولى رئاسته إلى أن انتقل إلى رحمة الله .

وقد زود المرحوم الدكتور الشرقاوى المكتبة العربية بعديد من المؤلفات الجغرافية .

وكان — رحمه الله — محباً لعمله عطوفاً على طلبته ، وفياً لزملائه وأصدقائه .

مصطفى عامر

مجلة
الجمعية الجغرافية المصرية

المجلد الثالث والثلاثون

١٩٦٠

الجمعية الجغرافية المصرية

شارع القصر العينى – مكتب بريد قصر الدوبارة
تليفون ٢٥٤٥٠

مجلة الجمعية الجغرافية المصرية

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المجلد الثالث والثلاثون

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